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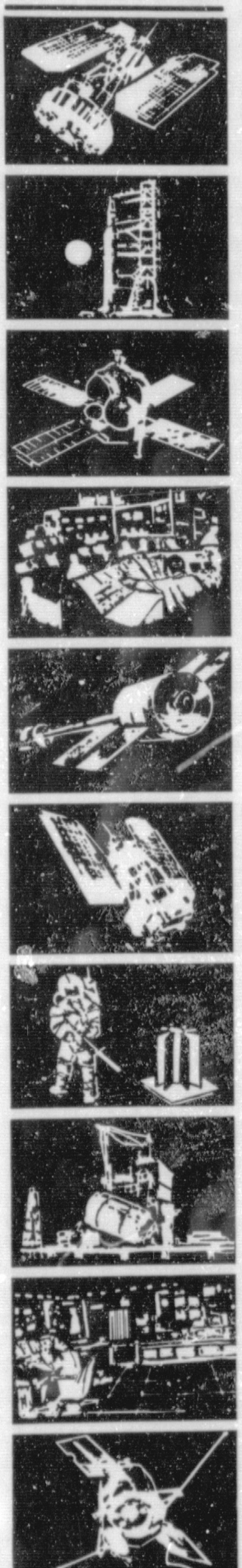

GE Report No. 76SDS4200
December 1975
NASA CR-
147483

# MODULAR BIOWASTE MONITORING SYSTEM

## FINAL REPORT

(NASA-CR-147483) MODULAR BIOWASTE MONITORING SYSTEM Final Report (General Electric Co.) 203 p HC $7.75 CSCL 06K

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

JOHNSON SPACE CENTER

HOUSTON, TEXAS 77058



GENERAL ELECTRIC

## Foreword

This report summarizes the Biowaste Monitoring System Flight Prototype Model Development. NASA technical direction was provided by Mr. R. L. Sauer, Contract Technical Monitor and by Mr. J. B. Westover.

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# MODULAR BIOWASTE MONITORING SYSTEM
# FINAL REPORT

## 1.0 SUMMARY

The objective of the Modular Biowaste Monitoring System Program was to generate and evaluate hardware for supporting SHUTTLE life science experimental and diagnostic programs. An initial conceptual design effort established requirements and defined an overall modular system for the collection, measurement, sampling and storage of urine and feces biowastes. This conceptual design effort was followed by the design, fabrication and performance evaluation of a flight prototype model urine collection, volume measurement and sampling capability. No operational or performance deficiencies were uncovered as a result of the performance evaluation test.

## 2.0 BACKGROUND

The acquisition of crew biomedical data has been an important task on all manned space missions from Project Mercury through the Skylab Program. The monitoring of biowastes from the crew is a valuable part of this activity. On early missions, emphasis was placed on the collection and return of biowaste samples for post mission analysis; on later missions such as Skylab, equipment for inflight measurement of urine/feces volume or mass was also added. For SHUTTLE, sampling and real-time measurements plus an increase in automation are anticipated requirements. The Modular Biowaste Monitoring System program, Contract NAS9-13748, was intended to be a first step in defining and developing biowaste monitoring hardware for use in the SHUTTLE ORBITER and/or SPACELAB programs.

The effort under Contract NAS9-13748 was accomplished in two steps. An initial conceptual design effort established requirements and defined an overall modular system for monitoring urine and fecal biowastes. This effort was followed by the design, fabriction and performance evaluation of flight prototype hardware for the collection, volume measurement and sampling of urine.

## 3.0 CONCEPTUAL DESIGN STUDY

The objective of the conceptual design study was to define requirements and generate a conceptual design for a Modular Biowaste Monitoring System for specifically supporting SHUTTLE life science experimental and diagnostic programs. Table 1-1 lists the general performance requirements for the system. These requirements were expanded, with the assistance of the NASA Technical Monitor, into a detail performance requirements specification.

Table 1-2 summarizes results of the conceptual design study. As noted, the modular concept as applied to the Biowaste Monitoring System is feasible and will permit scaling the system capability to fit the need for a specific SHUTTLE mission. Two independent baseline subsystems are recommended, a urine S/S for urine collection and volume measurement and a feces S/S for feces collection and mass measurement. These baseline configurations presume that, as a minimum, volume or mass measurement will be required to complement the urine and feces collection capability of the system. Eight other modules are proposed for extending the baseline capability to meet the full performance requirement of the Biowaste Monitoring System. These modules are for urine analysis and for urine and feces sampling and storage.

Table 1-1 Modular Biowaste Monitoring System General Performance Requirements

(a) The modular system shall provide for the collection and automatic sampling and storage of urine and feces.

(b) The modular system shall automatically measure urine volume and feces mass in real time.

(c) The modular system shall include an automatic capability for limited ($Na^+$, $K^+$, $Ca^{++}$, $Cl^-$ and TBD ions and pH) real time chemical analysis of individual micturitions.

(d) The modular system shall provide for multipersonal use, both male and female.

(e) The modular system shall be automated to minimize spacecraft crew time requirements.

(f) The system shall be modular in configuration so that functional capability can be easily increased or decreased depending on the life science requirements for a particular shuttle mission.

TABLE 1-2 SUMMARY, CONCEPTUAL DESIGN STUDY RESULTS

MODULAR APPROACH PRACTICAL

- 2 INDEPENDENT BASELINE S/S's
- 8 ADD-ON MODULES (URINE ANALYSIS, URINE AND FECES SAMPLING AND STORAGE AND FLUSH FLUID)
- TAILORED PLUMING/WIRING INTERCONNECT HARDWARE

POWER/WEIGHT MAY BE EXCESSIVE, PARTICULARILY FOR TOTAL CAPABILITY

- REVIEW SAMPLING REQUIREMENTS

  QUANTITY/TYPE/SIZE

  STORAGE VOLUME/TEMPERATURE

  FLUSH FLUIDS (CROSS-CONTAMINATION)

INTEGRATION WITH WCS PRACTICAL

- WCS CAN BE COMPLETELY INTEGRATED INTO BIOWASTE MONITORING SYSTEM
- POTENTIAL PROBLEM AREAS, REVIEW/DETERMINE

  EQUIPMENT LOCATION

  POWER AVAILABILITY

  FLUID DISPOSAL

These add-on modules, then, provide the necessary operating flexibility for meeting the anticipated variable experimental and diagnostic requirements of the SHUTTLE program. Each add-on module includes structural support elements with provision for mating with corresponding interface points in each baseline S/S assembly. However, each possible baseline S/S and add-on module combination will require a specifically tailored interconnect cabling and plumbing assembly.

Based on estimates for the total capability of the Biowaste Monitoring System and maximum mission conditions (6 men, 30 days), total weight and power (307 lbs. plus 445 lbs. of expendables and 565 watts peak) may be incompatable with SHUTTLE capability. Since the bulk of the weight and power required are to satisfy sampling requirements, a review of sample size, quantity and type, storage temperature and need for refrigerated storage and cross-contamination requirements is recommended.

Integration of the Shuttle Waste Collection System (WCS) with the Biowaste Monitoring System was investigated. As presently defined, the WCS is readily integrated into the Biowaste Monitoring System. Equipment commonality is excellent, however, a possible equipment installation problem exists for an integrated assembly.

The conceptual design study is covered in detail in GE report No. 74SD4254.

## 4.0 FLIGHT PROTOTYPE MODEL

The function of the BMS flight prototype model is to collect, measure the volume and sample urine from each micturition of selected SHUTTLE crew members.

Figure 4-1 shows the basic unit; Figure 4-2 the system block diagram. Major design requirements are summarized in Table 4-1.

## 4.1 Design

The BMS flight prototype model description and operation are as described in the O, M and H Manual, GE report No. 75SDS4217, included herein as appendix 6.1.

Specifications, analyses and design activity supporting the generation of flight quality drawings defining the BMS flight prototype model are reported in detail and chronologically in the following interim reports:

"Interim Design Status Report", December 1974,
GE Report No. 75SDS4203.

"Preliminary Design Review Report", January 1975,
GE Report No. 75SDS4206.

"Critical Design Review Report", May 1975,
GE Report No. 75SDS4224.

Other supplemental design information is included in appendix 6.2.

## 4.2 Fabrication And Assembly

The BMS prototype model was fabricated and assembled to substantially reflect the flight design in form and function. In some instances, commercial quality parts were substituted for high rel parts. Also the level of inspection was less then that normally employed for flight quality hardware. However, all critical dimensions were inspected to assure compliance with the drawings. In addition; limited burn-in of electronic parts was accomplished (see appendix 6.3).

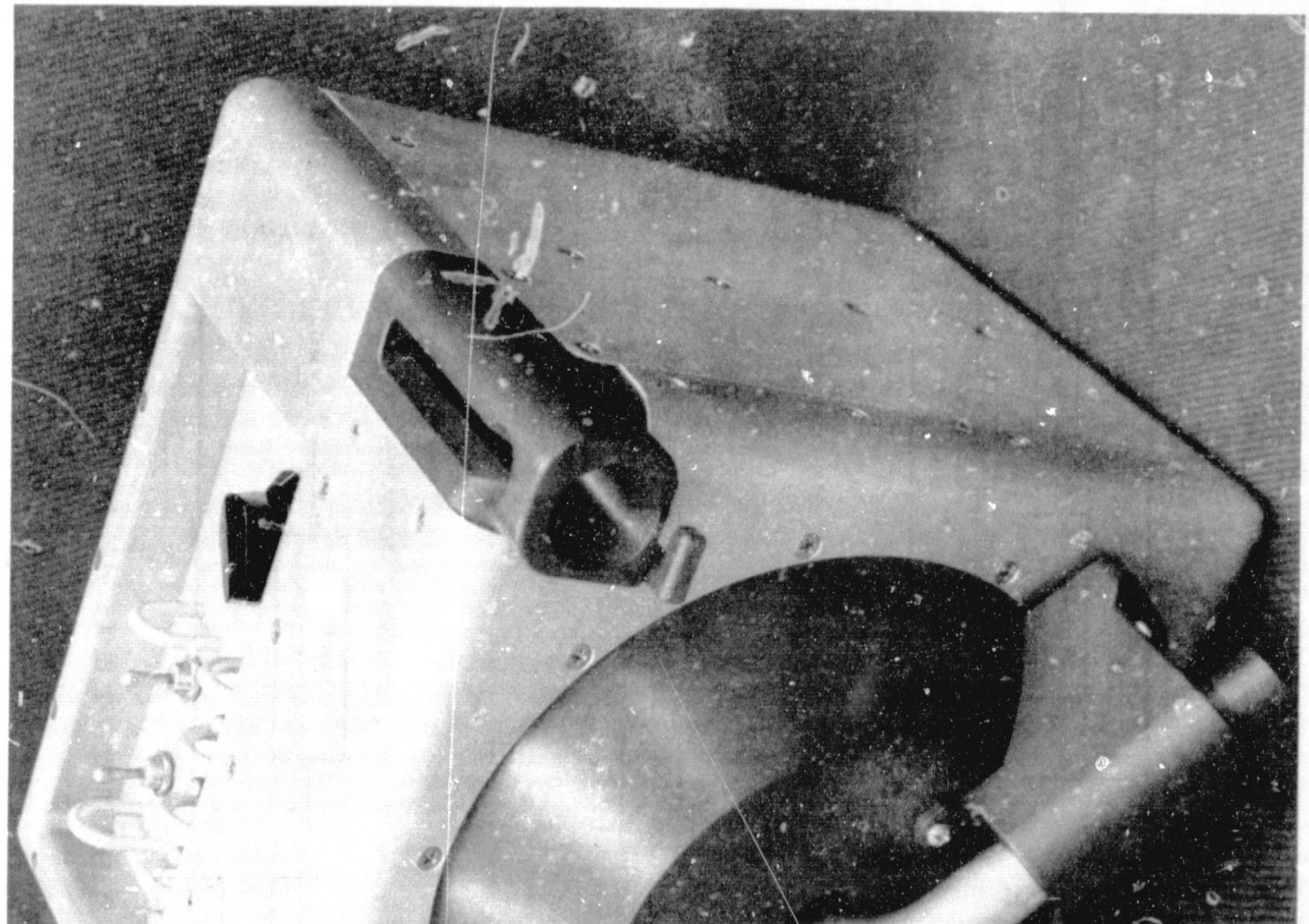

FIGURE 4-1 FLIGHT PROTOTYPE MODEL, LESS URINAL AND PORTABLE WATER RESERVOIR ASSEMBLIES

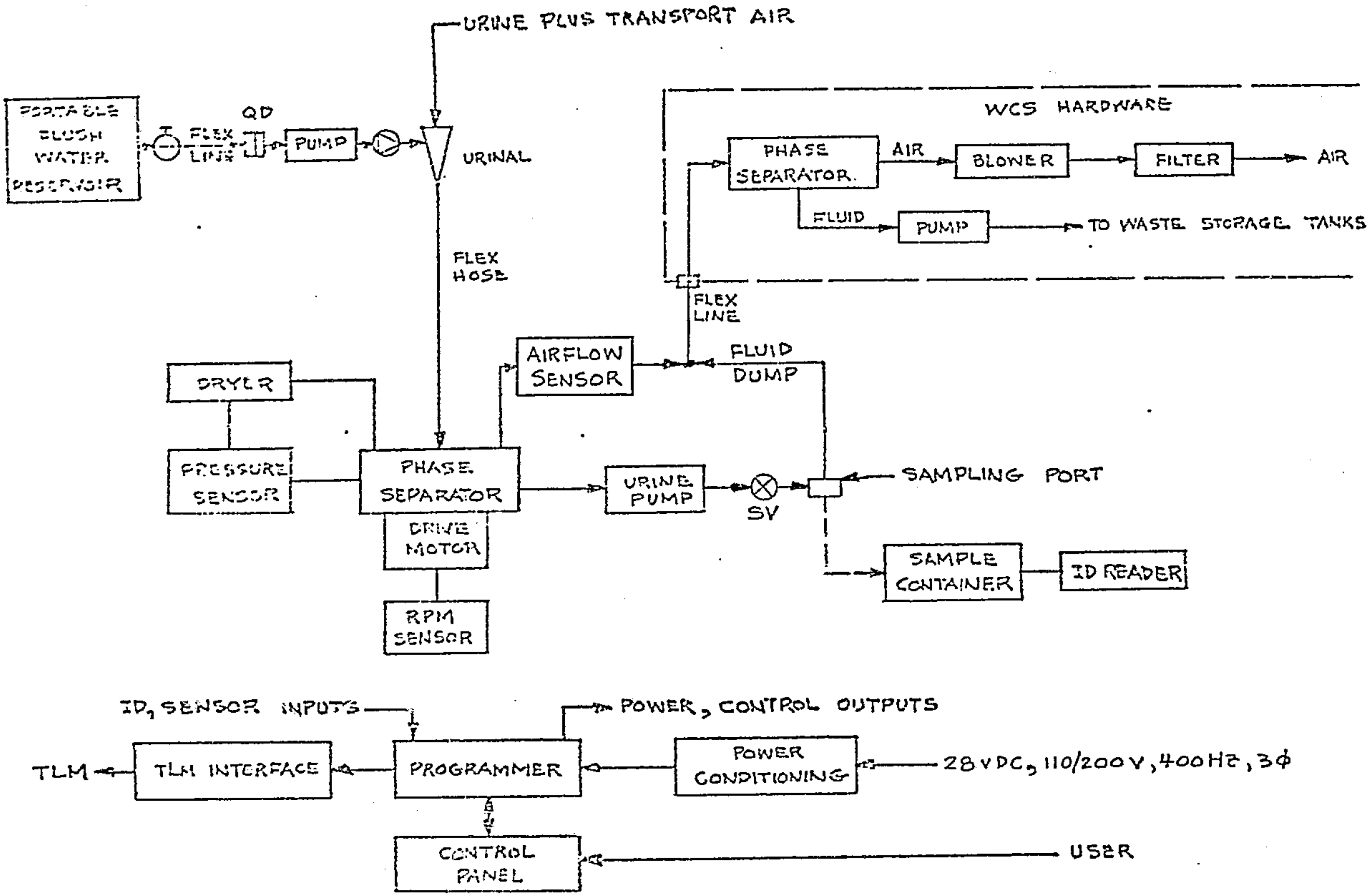


FIGURE 4-2 BMS FLIGHT PROTOTYPE BLOCK DIAGRAM

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Table 4-1 BMS Flight Prototype Major Design Requirements Summary

Urine Collection

- Male/Female Users
- Pneumatic Transport
- Micturition Volume
  - 1000 ml Maximum
  - 35 ml Minimum
- Micturition Rate
  - 25 ml/Second Maximum

Urine Volume Measurement

- Each Micturition
- Real Time
- Error, ± 2% Maximum (Of Actual Volume)

Urine Sampling

- User Option
- 0 to 20 ml (User Controlled)
- Chemical Additive (For Preservation)
- Cross-Contamination, 0.5 ml Maximum

System Operation

- Semi-Automatic
- 28 VDC and 115/200 Volt, 400 Hz, 3 Phase, 4 Wire Wye Connected Power
- Water Flush (For Cross-Contamination Control)
- WCS* Interconnection (For Transport Airflow and Fluid Dump)
- Data to TLM
  - Micturition Volume
  - User ID
  - Container Number
- Crew Size, 7 Users Maximum

*SHUTTLE Waste Collection System

Deviations in the flight prototype model from the flight design have been recorded. Broadly, these changer encompassed drawing errors, changes in cycle timing and substitution of a solenoid valve (Skinner type B2, two-way NC subminiature) for the check valve located downstream of the urine pump.

4.3 Performance Evaluation

Laboratory tests of the BMS flight prototype model were conducted to demonstrate operability under both normal and contingency operating modes and to obtain performance data. The tests were divided into four categories, i.e., operational procedures, volume measurement, sampling and mechanical/electronic. Test results are reported in detail in Appendix 6.4. No operational or performance deficiencies were uncovered.

4.4 Recommendations

Based on the experience with the flight prototype model, incorporation of several design changes into the final flight design is recommended. These are:

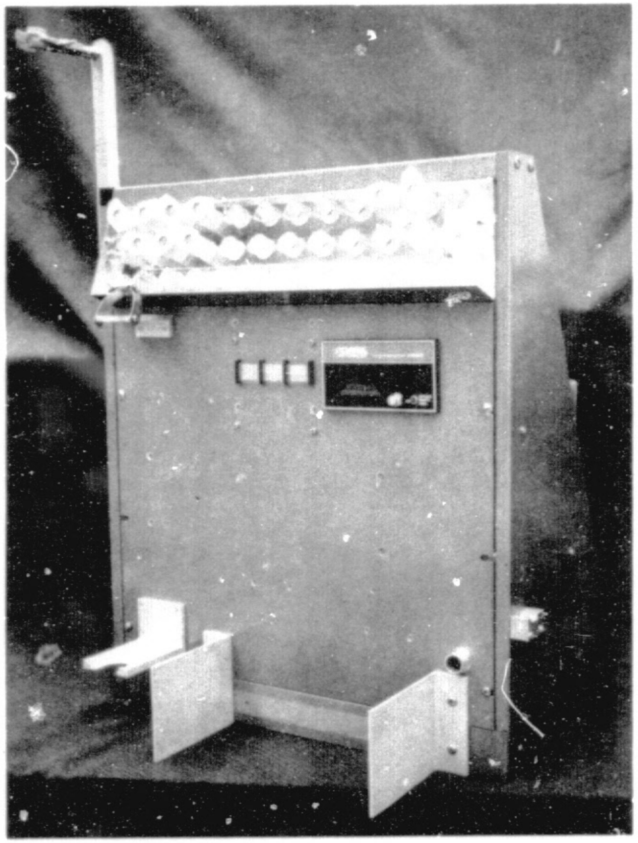
(a) Relocate the solenoid valve to a position downstream (instead of upstream) of the sampling port. This change will reduce the residual volume between the phase separator and sampling port, thereby increasing the effectiveness of the PURG cycle.

(b) Add a 15 second delay after initiation of PURG or DUMP cycles to prevent volume measurement and start of these cycles until the end of the delay period. This will assure stabilization of the fluid vortex in the phase separator before volume measurement occurs.

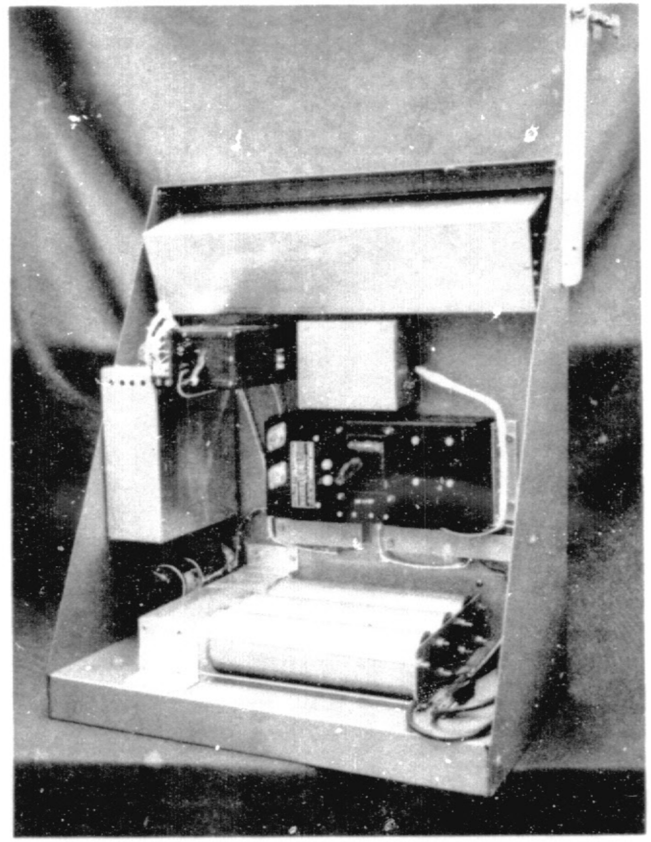
(c) Improve linearity of the volume measurement. Although not mandatory, the convenience of one equation (for calculating volume) over the current four equations is obvious. Also the number of calibration tests may be substantially reduced if the volume measurement is linear.

## 5.0 GROUND SUPPORT EQUIPMENT

To facilitate testing, both at GE and NASA, GSE as shown in Figures 5-1 and 5-2 and was designed and fabricated. The "console" controls power to the BMS flight prototype, provides a transport airflow and odor filtering capability plus TLM decoder and paper tape recorder and provides a convenient mounting and stowage arrangement for the flight prototype model. Additional information is included in appendix 6.5.



FRONT VIEW



BACK VIEW

FIGURE 5-1  GROUND SUPPORT EQUIPMENT (PLUS BMS SAMPLE CONTAINERS)

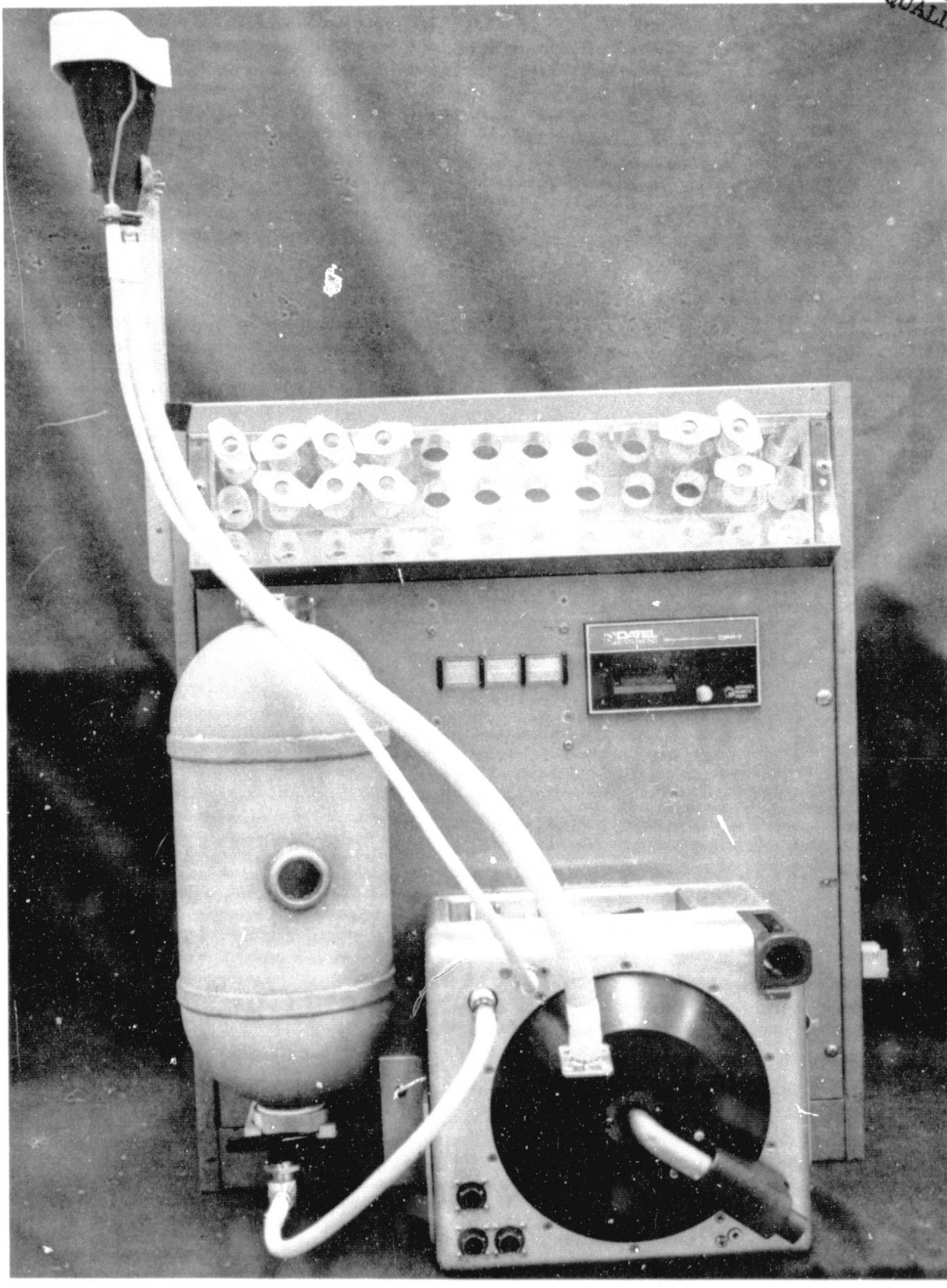


FIGURE 5-2 GROUND SUPPORT EQUIPMENT WITH BMS FLIGHT PROTOTYPE HARDWARE ATTACHED

*m.*

## 6.0 APPENDIX

6.1 O, M and H Manual, GE Report No. 75SDS4217.

PRELIMINARY

GE Document No. 75SDS4217
December 1975

# MODULAR BIOWASTE MONITORING SYSTEM

FOR

SHUTTLE ORBITER

OPERATING, MAINTENANCE

AND

HANDLING PROCEDURES

CONTRACT NAS9-13748

General Electric Company
Space Division
Valley Forge Space Center
P. O. Box 8555
Philadelphia, Pennsylvania 19101

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## Foreword

This document defines the Operating, Maintenance and Handling procedures for the SHUTTLE ORBITER Biowaste Monitoring System. NASA technical direction was provided by Mr. R. L. Sauer, Contract Technical Monitor, and Mr. J. B. Westover.

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PRELIMINARY

# PART I - SYSTEM DATA

## 1.0 GENERAL DESCRIPTION

The basic function of the Biowaste Monitoring System (BMS) is to support SHUTTLE ORBITER life science experimental and diagnostic programs. This is accomplished thru the collection, volume measurement and sampling of urine from each micturition of selected crew members. Major system design requirements are summarized in Table 1-1.

Figure 1-1 illustrates the functional aspects of the BMS. The system equipments for performing these functions are, with three exceptions, contained within one integrated assembly as shown in Figure 1-2. A urinal assembly and portable flush water reservoir assembly are located TBD; sample containers, prior to and after use, are stored TBD.

Interfaces with the SHUTTLE ORBITER are summarized in Table 1-2. Figures 1-3 and 1-4 show the location of the system for both launch and operational use. For launch and until deployed for operational use, the system will be stored TBD; for operational use, the system will be located TBD. The sample containers, after use, may be stored at ambient conditions or refrigerated.

Table 1-1. BMS Major Design Requirements Summary

Urine Collection

- Male/Female Users
- Pneumatic Transport
- Micturition Volume
  - 1000 ml Maximum
  - 35 ml Minimum
- Micturition Rate
  - 25 ml/Second Maximum

Urine Volume Measurement

- Each Micturition
- Real Time
- Error, ± 2% Maximum (Of Actual Volume)

Urine Sampling

- User Option
- 0 to 20 ml (User Controlled)
- Chemical Additive (For Preservation)
- Cross-Contamination, 0.5 ml Maximum

System Operation

- Semi-Automatic
- 28 VDC and 115/200 Volt, 400 Hz, 3 Phase, 4 Wire Wye Connected Power
- Water Flush (For Cross-Contamination Control)
- WCS* Interconnection (For Transport Airflow and Fluid Dump)
- Data to TLM
  - Micturition Volume
  - User ID
  - Container Number
- Crew Size, 7 Users Maximum

*SHUTTLE Waste Collection System

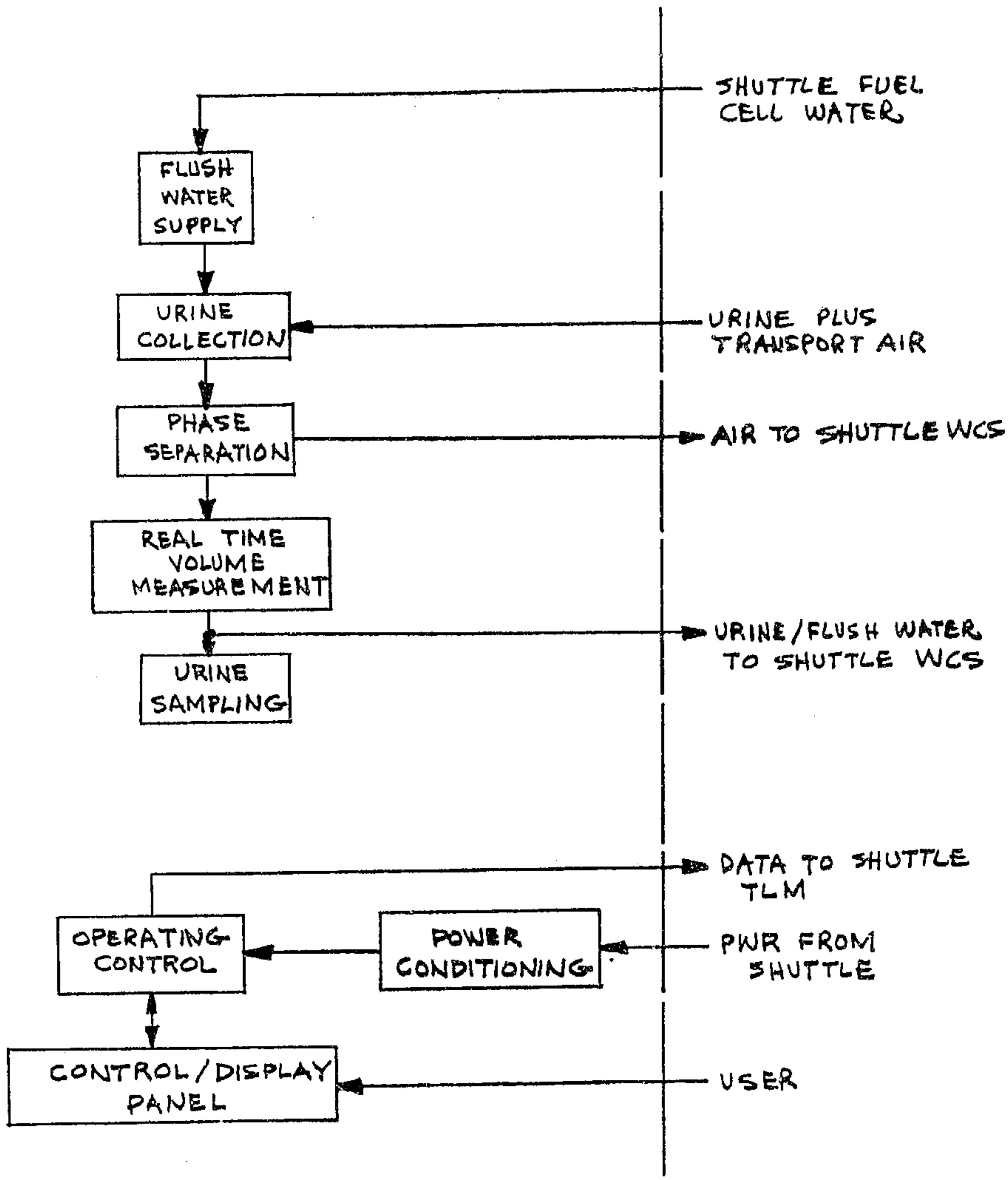



FIGURE 1-1 BMS FUNCTIONAL BLOCK DIAGRAM

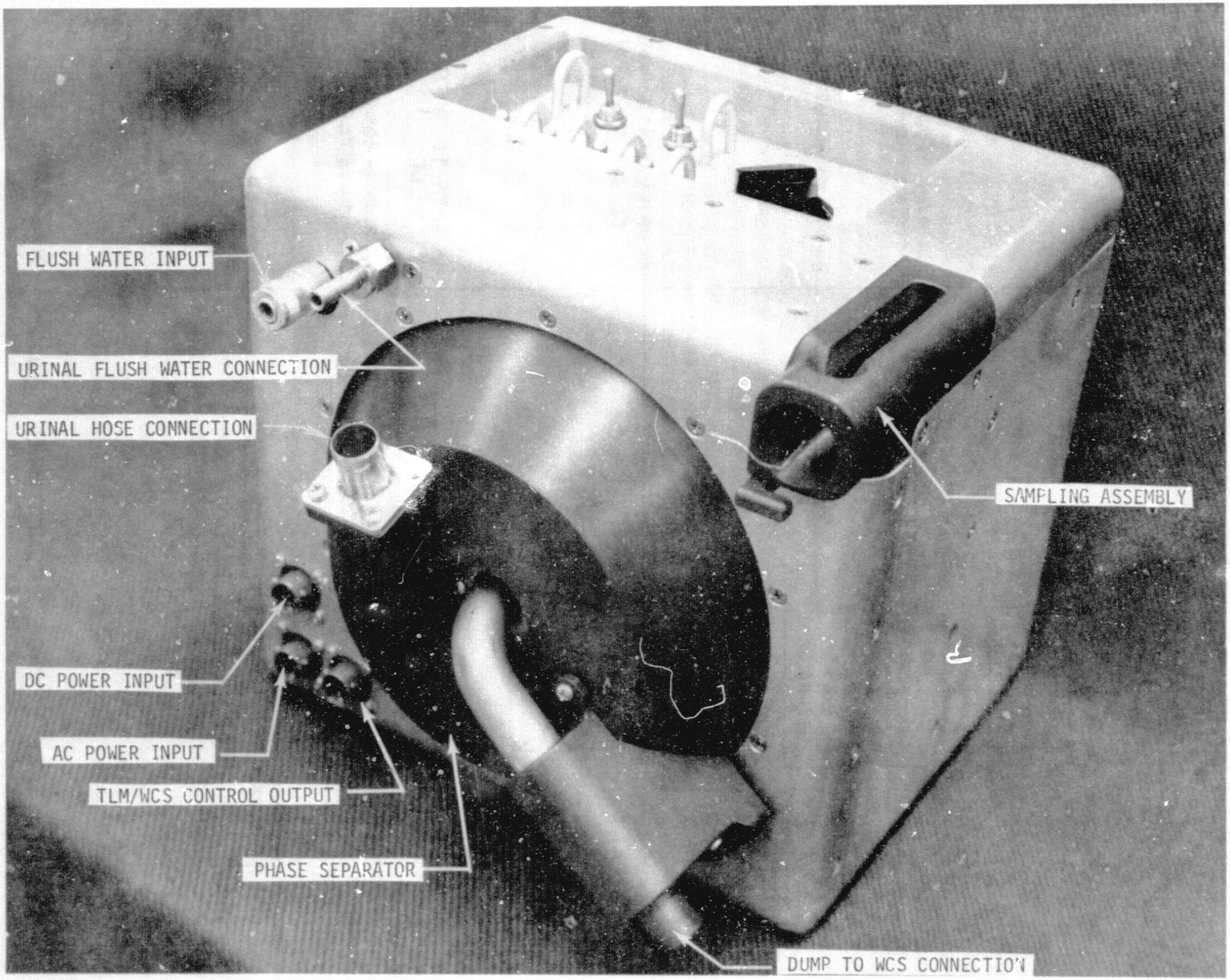



FIGURE 1-2 BMS ASSEMBLY (LESS URINAL, SAMPLE CONTAINER AND PORTABLE WATER RESERVOIR ASSEMBLIES)

## Table 1-2. SHUTTLE ORBITER/BMS Interface Summary

Location (Operational)

- Adjacent to WCS
- Sample Container Storage TBD

Mechanical

- Fuel Cell Water Supply Via QD
- WCS Via Flex Hose

  Transport Airflow
  Fluid Dump

Electrical

- 28 VDC and 115/200 Volt, 400 Hz, 3 Phase, 4 Wire Wye Connected Power, Panel Location TBD

  TBD Watts Maximum (Peak)
  TBD Watts Average

Communication

- TLM Input

  Micturition Volume
  User ID
  Sample Container Number

Environmental

- Thermal Energy Rejected to Ambient

  TBD BTU/Hour Average

TBD

FIGURE 1-3. BMS LAUNCH INSTALLATION

TBD

FIGURE 1-4. BMS OPERATIONAL INSTALLATION

## 2.0 SYSTEM ELEMENTS

### 2.1 System Operation

Figures 2-1 illustrate the system block diagram. Briefly, the system operating sequence for urine collection, volume measurement and sampling is as follows:

a. The user activates the BMS. This supplies power to the various system elements and automatically activates the WCS. This latter action provides the transport airflow and waste fluid dump source necessary for operating the BMS.

b. The user adjusts the urinal and micturates.

c. During micturition, the phase separator conditions and stores the incoming urine. Conditioning consists of transport air removal, gross particulate filtering and mixing to achieve a homogeneous urine mixture.

d. When micturition is completed, the user replaces the urinal and initiates the purge cycle. Volume measurement data are obtained at initiation of the purge cycle.

e. The purge cycle replaces the fluid residual in the urine pump, sampling port and associated plumbing with urine from the just completed micturition.

f. The user installs a sample container.

g. The user controls filling of the sample container via manual control of urine pump action.

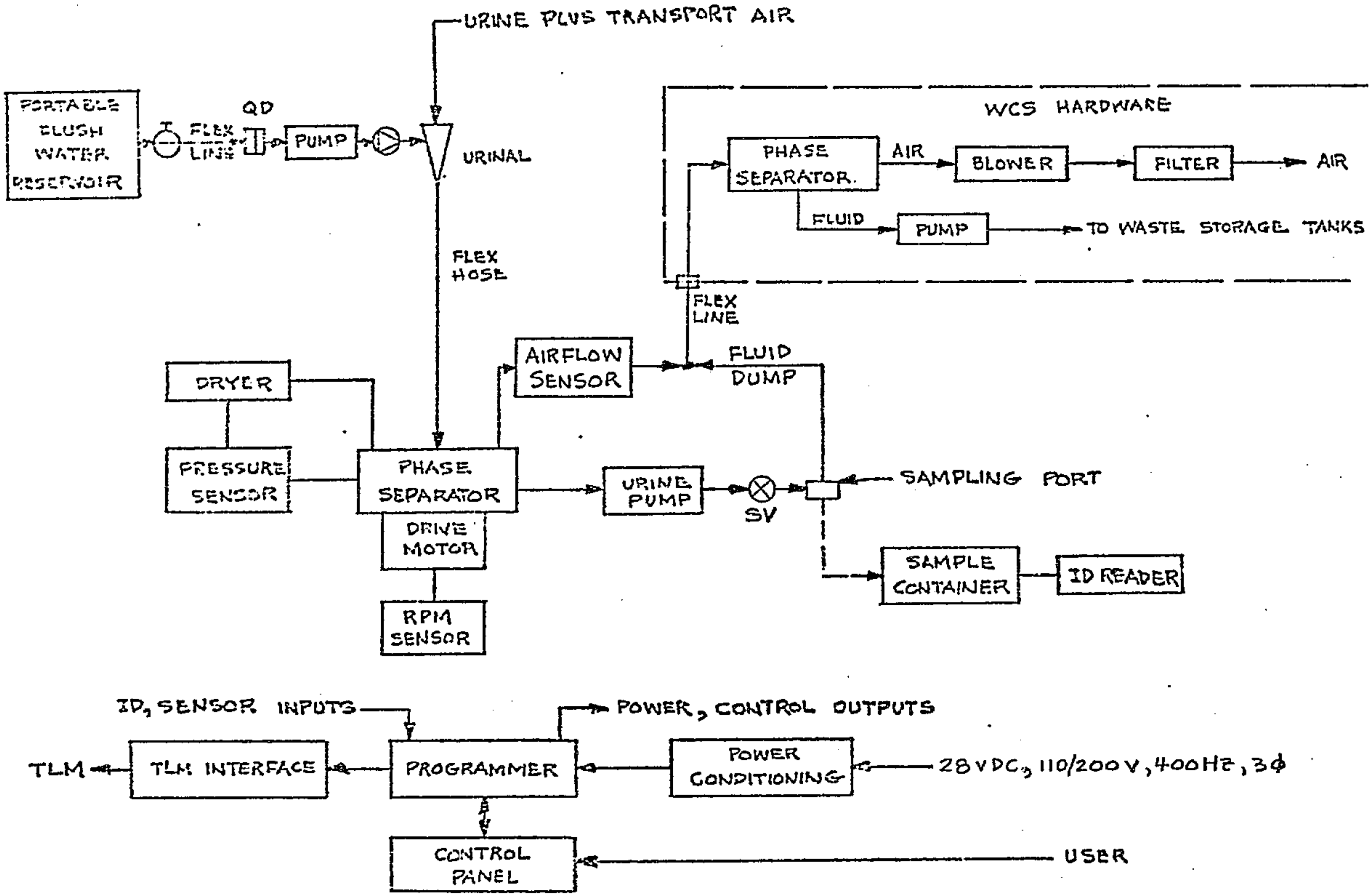



FIGURE 2-1 BMS BLOCK DIAGRAM

h. The user removes the filled sample container.

i. The user initiates the dump cycle, causing the remaining urine to be pumped from the phase separator to the WCS for disposal.

j. Volume measurement data, user ID and sample container number are automatically sent to the TLM connection. This event occurs at the completion of the dump cycle.

k. At completion of the dump cycle, a water flush cycle is automatically initiated. Water from the flush water reservoir is flushed thru the system to remove the urine residual and thus minimize cross-contamination between samples.

l. After completion of the flush cycle, the system (and WCS) is automatically deactivated, ready for the next user.

The above sequence is shown in Figures 2-2 and 2-3 and is defined in greater detail in Part II and in the Appendix of this document. Note that most functions performed by the system are accomplished automatically but with each step manually initiated by the user. Also, sampling is at the option of the user in which case the purge and sampling cycles are omitted.

## 2.2 Element Description

Functionally, the BMS can be divided into some six areas, (1) urine collection, (2) phase separation, (3) volume measurement, (4) sampling, (5) water flush, (6) and control logic and power conditioning. Equipments to implement these functions, with the exception of the portable flush water tank, are packaged in a single assembly of approximately 0.5 $ft^3$ and with overall dimensions of 9 X 10 X 10.5 inches. When mounted for operational use, one surface will be

| FUNCTION | FUNCTION INITIATION |
|---|---|
| POWER VIA CKT BKR | |
| POWER ON VIA COLL SWITCH ACTUATION (PHASE SEPARATOR, ELECTRONICS ACTIVATED; WCS ACTIVATED VIA BMS) | USER |
| SET USER ID SELECT SWITCH | USER |
| OPERATING STATUS CHECK | AUTOMATIC |
| POSITION URINAL/MICTURATE | USER |
| ACTUATE PURGE SWITCH | USER |
| OBTAIN VOLUME MEASUREMENT DATA | AUTOMATIC |
| URINE PUMP ON | AUTOMATIC |
| INSTALL SAMPLE CONTAINER | USER |
| ACTUATE SAMP SWITCH TO FILL SAMPLE CONTAINER | USER |
| REMOVE SAMPLE CONTAINER | USER |
| ACTUATE DUMP SWITCH | USER |
| URINE DUMP TO WCS | AUTOMATIC |
| FLUSH CYCLE | AUTOMATIC |
| POWER OFF, SYSTEM READY FOR NEXT USER | AUTOMATIC |
| DATA TO TLM (VOLUME DATA, USER ID, SAMPLE CONTAINER ID) | AUTOMATIC |
| ACTUATE DUMP SWITCH | USER |
| OBTAIN VOLUME MEASUREMENT DATA | AUTOMATIC |
| URINE DUMP TO WCS | AUTOMATIC |
| FLUSH CYCLE | AUTOMATIC |
| POWER OFF, SYSTEM READY FOR NEXT USER | AUTOMATIC |
| DATA TO TLM | AUTOMATIC |

Figure 2-2 BMS Operating Sequence Summary

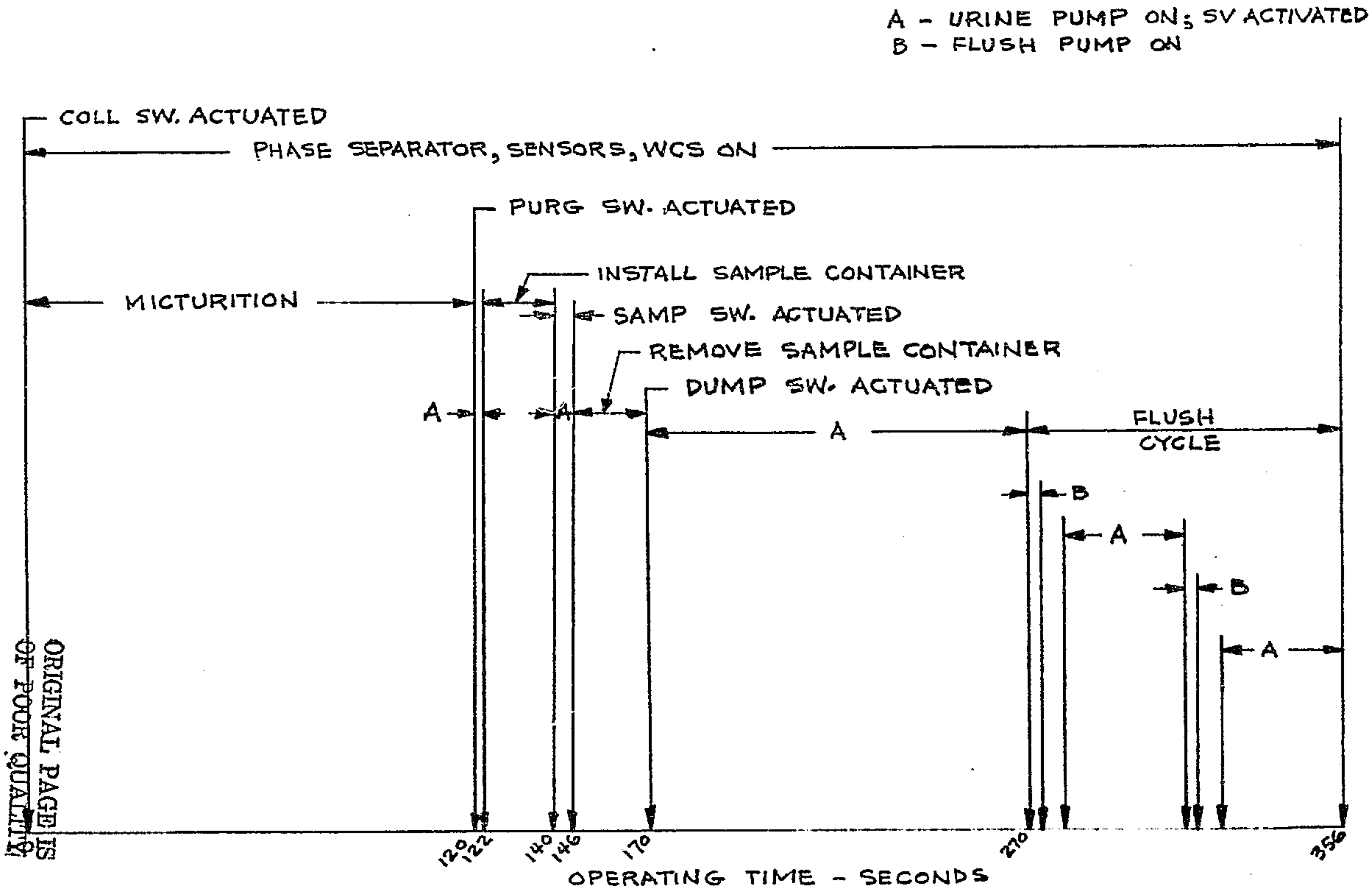



FIGURE 2-3 TOTAL ESTIMATED BMS OPERATING TIME AFTER MICTURITION

secured to the deck immediately adjacent to the WCS. Total weight of the dry assembly (less sample containers) is 26.3 lbs.

The basic BMS assembly consists of the functional elements mounted within an aluminum structure on appropriately located support members. Protective aluminum panels are provided for enclosing the structure, certain of which are removable as required for maintenance. For safety considerations, electronic and fluid components are isolated from each other and the habitable environment. All interface connection points are mounted on one side of the structure. These provide connections fo the flush water reservoir, power/telemetry cable, WCS dump connection and WCS ON-OFF control.

### 2.2.1 Urine Collection

Figure 2-4 shows the hardware used for urine collection, consisting essentially of a funnel shaped urinal and dual flex hoses. All incoming fluid (urine or flush water) is conveyed by the transport air thru the larger diameter flex hose from the urinal and into the phase separator. The smaller flex hose directs flush water from the flush water pump to the urinal. The flush water enters the urinal from two small spray nozzles. The nozzles are spaced and oriented to cover the inner surface of the urinal with a film of flush water. The transport airflow prevents escape of the flush water into the environment.

The urinal is a contact (fitted) type suitable for both male and female users. The urinal may be hand held or mated to the WCS urinal position adjustment mechanism. This latter mode is recommended for users in the seated position. For female use, whether hand held or mated to the WCS

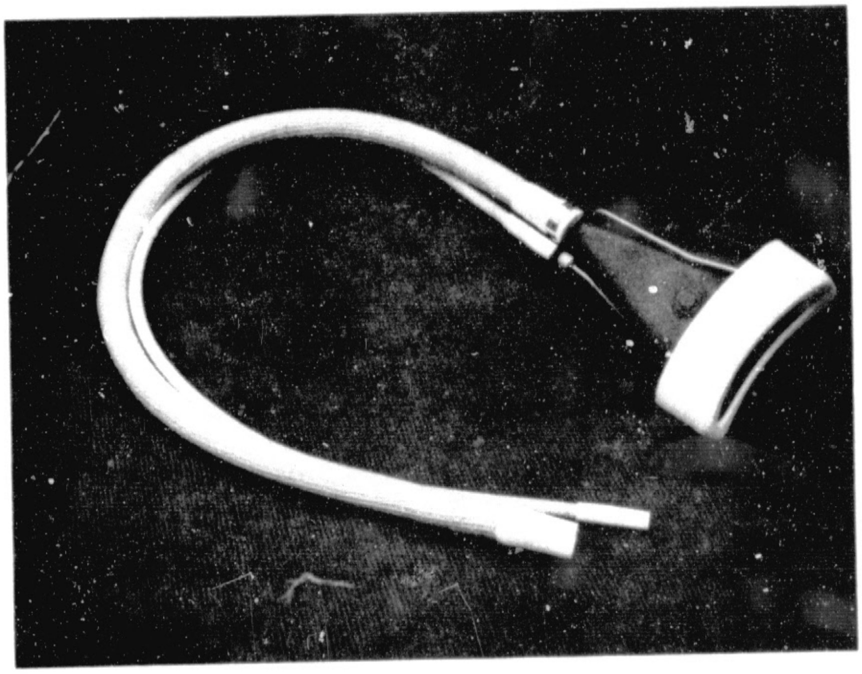


FIGURE 2-4 (a). BMS URINE COLLECTION

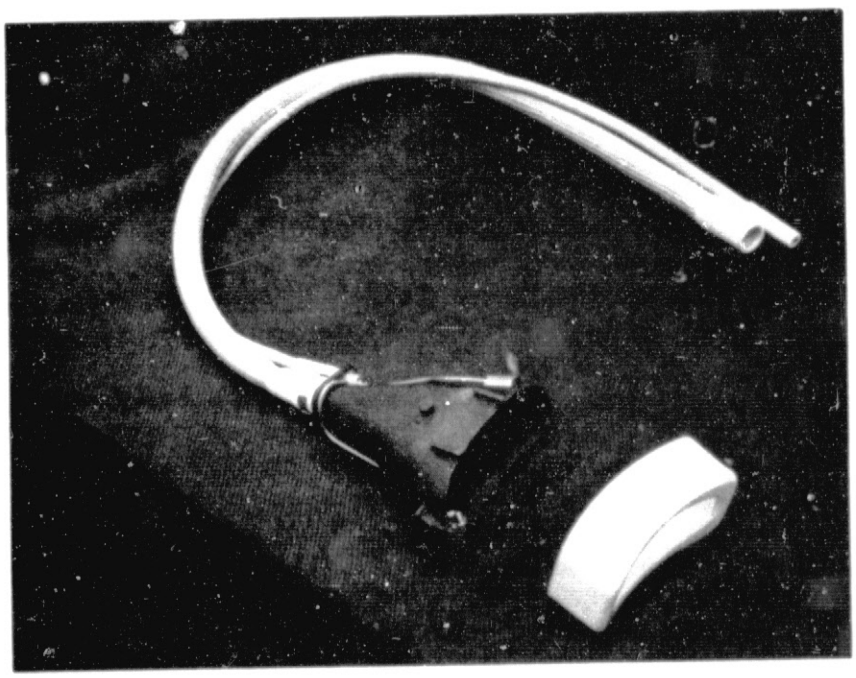


FIGURE 2-4 (b). BMS URINE COLLECTION ASSEMBLY (INTERFACE CAP REMOVED)

adjustment mechanism, the urinal must be positioned against the user with about a 7 to 10 lb. force (automatically provided by WCS position adjustment mechanism). This approach provides positive urine containment. Also, the positioning force results in the labia being opened thereby assuring a more integrated, direct flow of urine. For female use, the transport air enters the urinal along a flow restrictive circumferential opening. The resulting high velocity airflow, directed at the labia/vulva area and the opening of the labia (as noted above), effectively removes any urine residual.

Protection of users from microbiological cross-contamination is an important consideration. The BMS accomplishes this protection by personalizing the interface between the urinal opening and the user. Each user is provided with his or her urinal interface cap. The personalized interface cap is placed over the urinal opening (snap fit) and removed after micturition is completed. The interface cap may be cleaned and/or sanitized by the user as required or desired.

### 2.2.2 Phase Separation

The phase separator assembly is shown in Figure 2-6 and consists of the phase separator, phase separator motor drive, pressure, rpm and airflow sensors and dryer. The major functions of the phase separator are to store and condition the incoming urine prior to sampling and/or volume measurement. Conditioning consists of transport air removal, gross particulate filtering and mixing (to assure a homogeneous urine mixture).

The phase separator is a dynamic type, utilizing a rotating impellor within a stationary outer housing. The centrifugal action caused by the rotating impellor forms a liquid (urine) vortex within the inner periphery of the stationary housing, the transport air being removed from the center of the

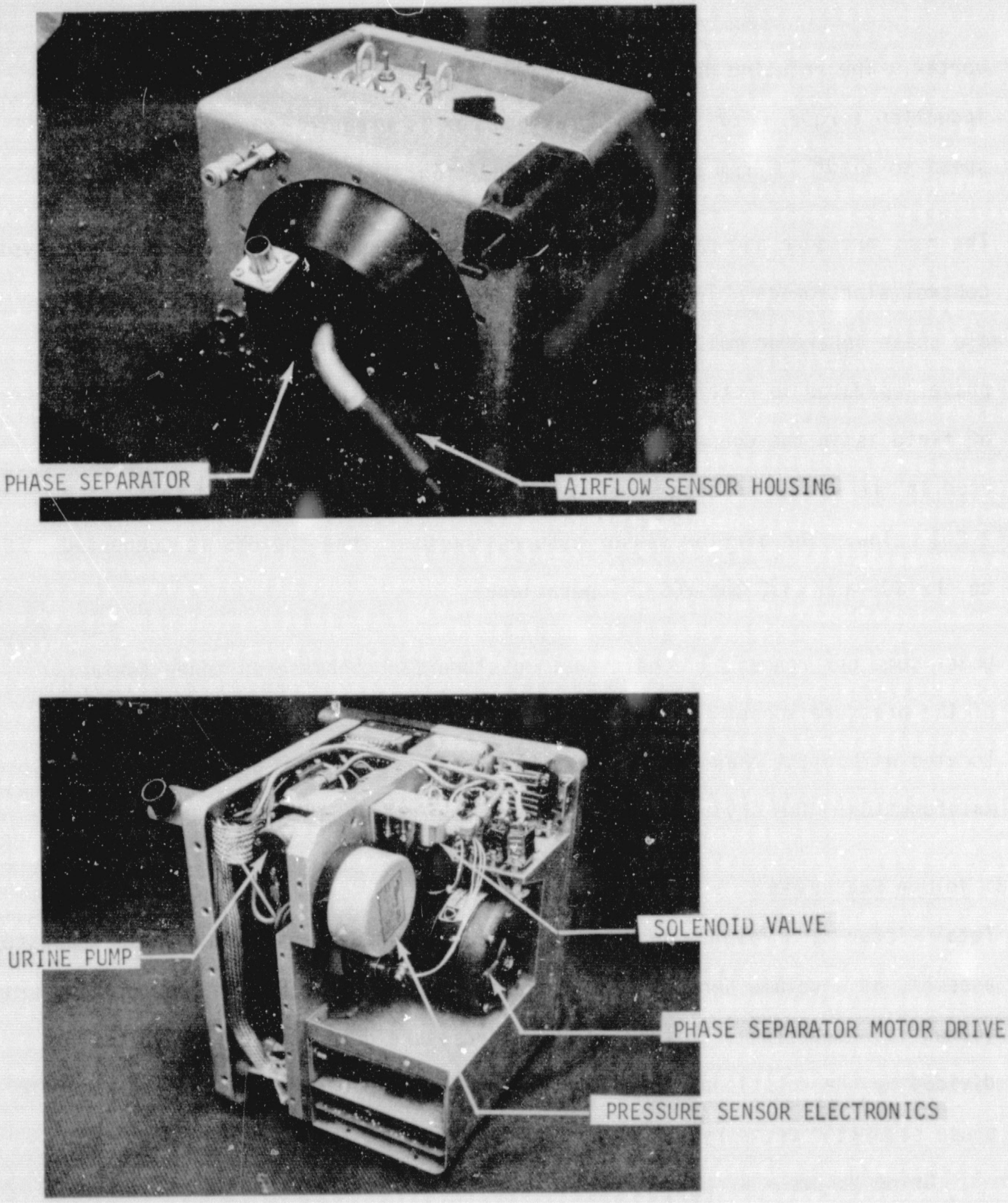



FIGURE 2-6. PHASE SEPARATOR ASSEMBLY

vortex. The rotating impellor is driven by a 200 volt, 3 phase, 400 HZ induction torque motor. An integral gearbox is used to reduce the output speed to about 400 rpm under no load condition.

The rpm, pressure and airflow sensors provide diagnostic information to the system control electronics. The rpm and pressure sensors alert the user to possible phase separator malfunction conditions. This assures the user that the phase separator is rotating and that no more than a minimal residual volume of fluid is in the phase separator. The pressure and rpm sensors are also used in the system to determine volume measurement data as noted in Section 2.2.3 below. The airflow sensor assures the user that the BMS is connected to the WCS and that the WCS is operational.

Under some environmental conditions, moisture can condense on inner surfaces of the pressure sensor and thereby cause a malfunction. A silica gel dryer, located within the phase separator housing, is provided to prevent this type malifunction. The dryer is sized for the maximum SHUTTLE ORBITER mission.

### 2.2.3 Volume Measurement

Total micturition volume measurement is accomplished by using the phase separator assembly as a volume sensor. The instantaneous fluid volume in the rotating urine vortex is proportional to the peripheral pressure generated by the vortex divided by the rotational speed of the impellor squared. Thus for the specific phase separator geometry,

$$\text{Urine Volume} = K\left(\frac{P}{SW^2}\right)^X \qquad (1)$$

where $P$ = vortex peripheral pressure, psi

$W$ = Impellor rotational velocity, rad/sec.

$S$ = urine specific gravity

$K$ and $X$ = constants (values as determined for each specific BMS assembly)

When micturition is completed, as indicated by user initiation of the purge or dump cycles (see operating sequence in Part II of this document), volume measurement data, i.e. vortex pressure and rotational velocity, are stored for subsequent dump to the SHUTTLE ORBITER TLM system. When received at the ground station, this data is combined (assuming an average value for S) using equation (1) to give the total micturition volume. When specific gravity data is available from post flight analysis of the urine samples, the volume measurement may be recalculated using the actual value of S.

2.2.4 Sampling

The sampling assembly and typical sample container are shown in Figures 2-7 and 2-8. The sample container is similar to that of a common laboratory syringe. If a sample is desired, the user inserts the sample container into the sampling assembly so that the container "needle" penetrates the duck bill septum in the sampling port. Needle penetration continues until the needle contacts the tip seal, thereby blocking the outlet flow parth. The sample container is then rotated 90° to lock it in position. If this rotation is not accomplished, urine pump action is inhibited and the sample container cannot be filled. On user command via the SAMP switch, the urine pump forces urine into the sample container via the needle, moving the sample container piston toward the filled end. The sample size, up to 20 ml maximum, is controlled by the user via the SAMP switch. The sample container is back lighted to assist the user in visually estimating the sample size. In case of an overfill malfunction, the piston is positively retained in the sample container; the container is designed to withstand the maximum pressure capability of the urine pump. The sample container is coded with an identification number which is read by an optical ID reader integral with the sampling assembly. When the sample container is filled, the user removes the sample container from the sampling assembly, caps the needle and transfers the container to

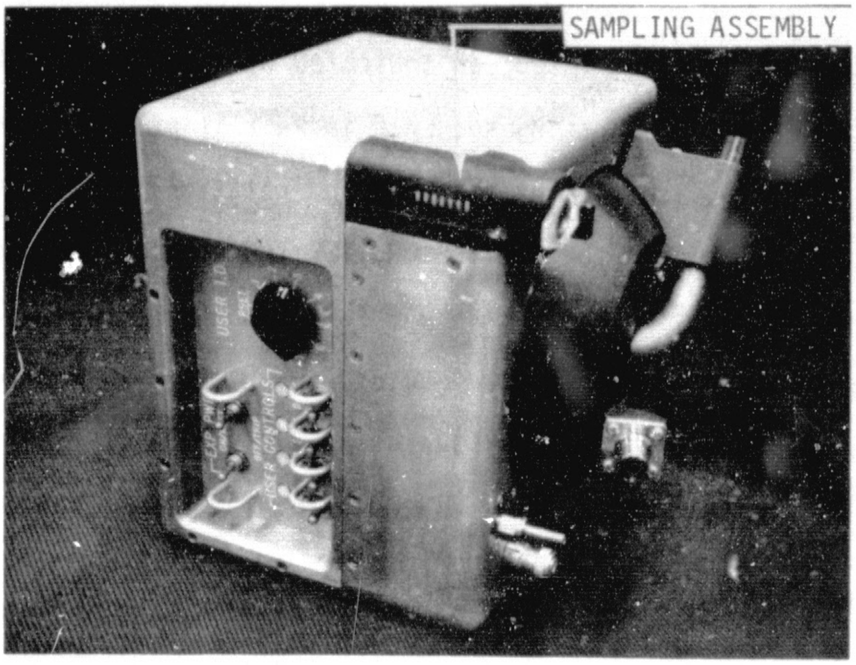



FIGURE 2-7. SAMPLING ASSEMBLY

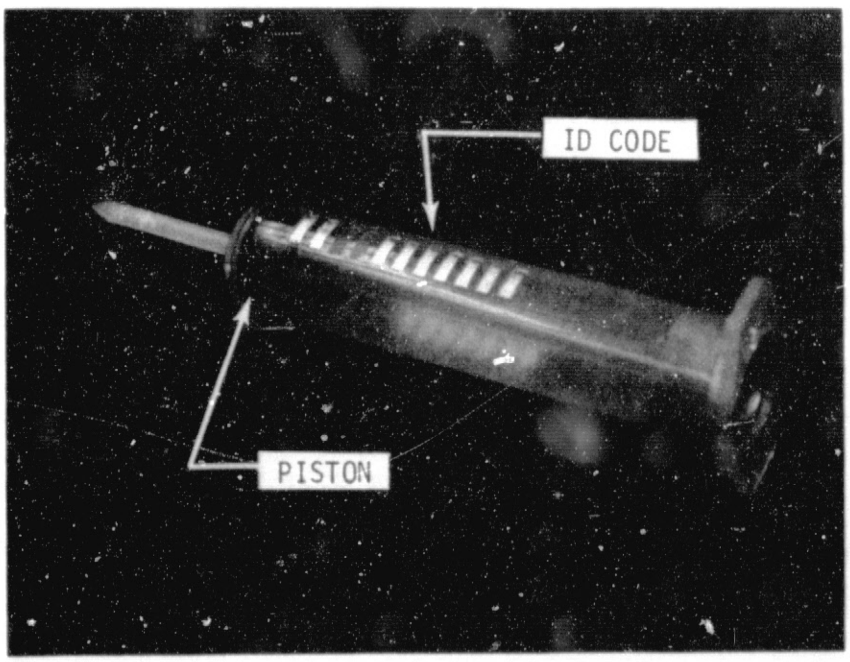



FIGURE 2-8. SAMPLE CONTAINER

storage. Note that the position of the piston is a ready visual indication of the use condition of the sample container.

### 2.2.5 Cross-Contamination Control

#### 2.2.5.1 Purge

At the completion of the previous BMS use cycle, the urine pump, solenoid valve, sampling port and connecting tubing are filled with a flush water/urine mixture. This residual mixture is predominately flush water; the urine constituent (from the preceeding micturition) will be less than 0.5 grams of the total. If a urine sample is desired, this residual mixture must be purged from the system. This is accomplished automatically on user command (by actuation of the PURG switch). Actuation of the PURG switch operates the urine pump for a fixed time period (1.6 seconds) sufficient to dump the residual mixture to the WCS. Thus at the end of the purge cycle, the urine pump, solenoid valve, sampling port and connecting tubing a filled with "fresh" urine and the sampling cycle can be accomplish without significant cross-contamination of the sample.

#### 2.2.5.2 Flush

The last function to be accomplished during a system use cycle is a water flush. This water flush of the entire system is provided to minimize the urine residual remaining in the system and thus minimize cross-contamination from sample to sample. The water flush also minimizes odors due to urine decomposition and microorganism growth.

The equipments for accomplishing this function are a portable flush water reservoir (See Figure 2-9), and motor driven pump. The portable tank is a bladder type design having a capacity of 5 liters of water. This capacity

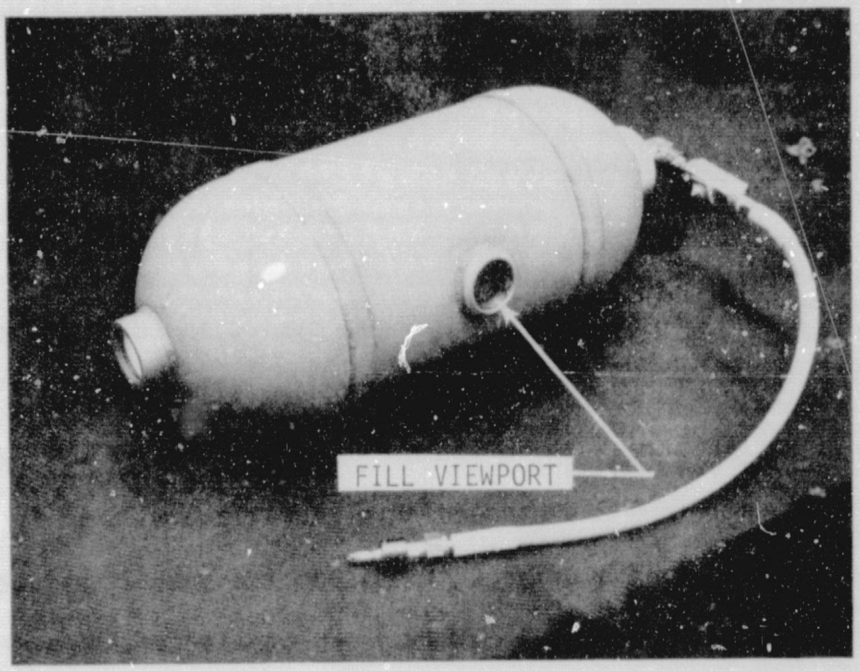



FIGURE 2-9(a). PORTABLE FLUSH WATER TANK ASSEMBLY

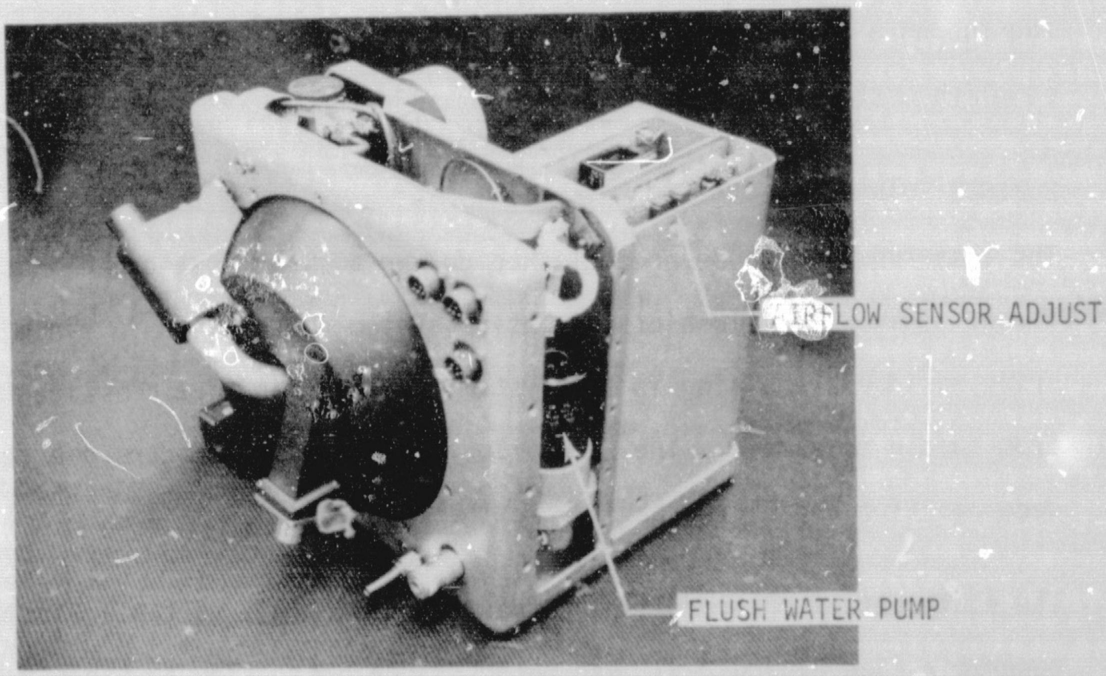



FIGURE 2-9(b). FLUSH WATER PUMP

is sufficient for one day of operational use of the system under maximum (7) user conditions. However, refilling on a 24-hour cycle is required. Fuel cell product water (or equal) is used for the supply; attachment is via the flex hose and quick disconnect connector. Water flushing of the system is accomplished automatically at the end of the dump cycle. The pump pressurizes water from the reservoir, the water entering the system via the urinal. About 60 ml of water are used per flush; two flushes are required for a complete flush cycle after each system use.

### 2.2.6 Control

Figure 2-10 shows the system electronics package. This package contains the power conditioning ciruitry and logic for controlling the various system operations. The user initiates the various steps in the system operating cycle via the control/display panel, see Figure 2-11. Thus on commands from the user, via the control panel, the electronics automatically directs the urine collection, purge, volume measurement, sampling and water flush functions. The various system sensors provide feedback information. This information is electronically correlated and forms the basis for the next step in the cycle.

The control/display panel provides the operating interface between the user and the system. As such, the displays provide system operating information to the user while the controls provide the means for the user to initiate system actions. Controls are minimal, consisting of four toggle switches with corresponding status lights, two circuit breakers and a multi-position user identification selector switch. The latter is designed to minimize user ID error by requiring rotation to the RSET position before setting to the user's ID number.

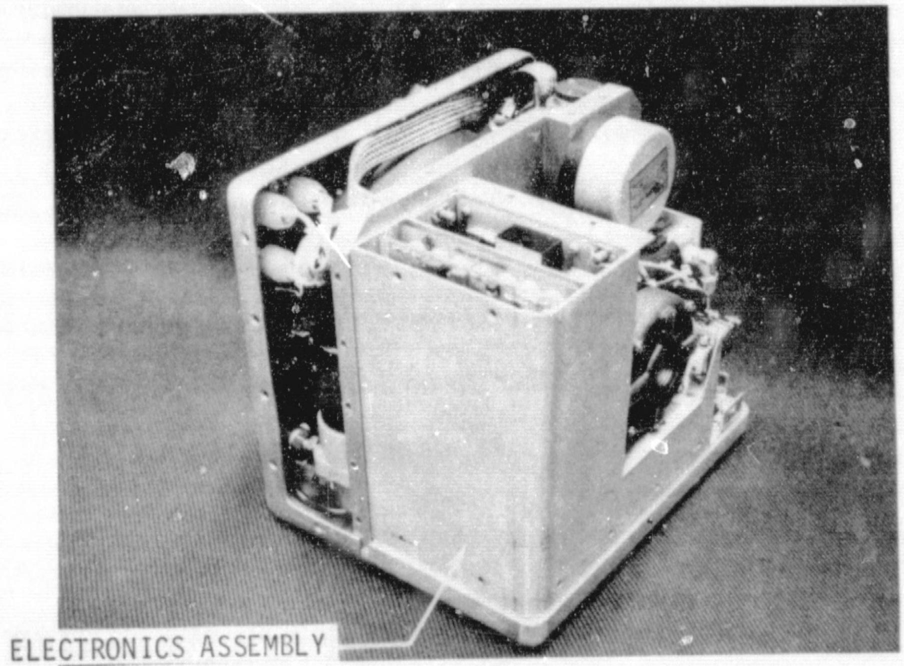



FIGURE 2-10 BMS ELECTRONICS

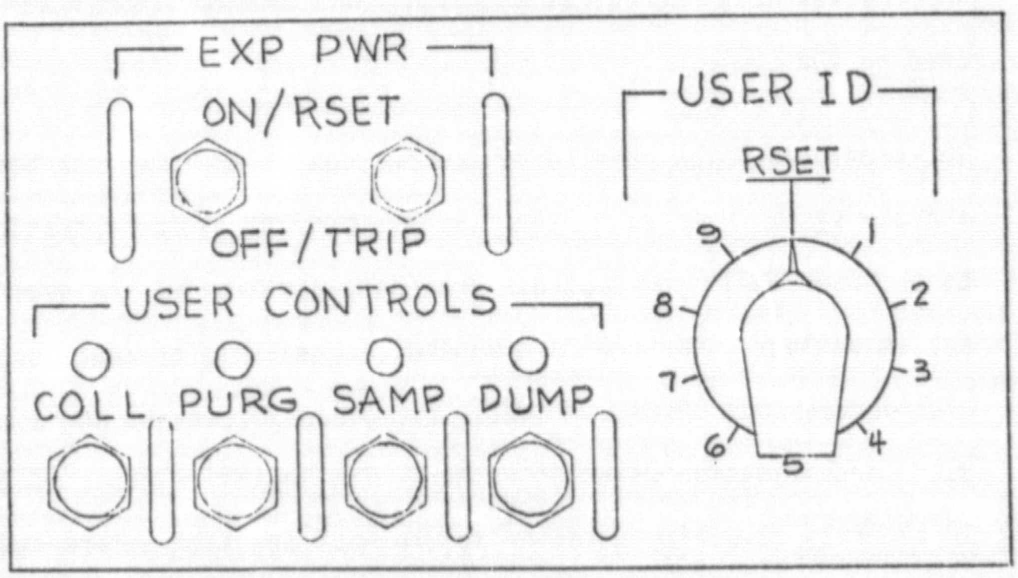



FIGURE 2-11 CONTROL/DISPLAY PANEL

Five malfunction conditions are indicated by a flashing condition of the COLL switch status light. A check for these malfunction conditions is automatically made immediate following user activation of the COLL switch. Phase separator rpm, the presence of fluid in the in the phase separator and transport airflow from the WCS are checked by built-in test sensors. A low phase separator rpm indicates probably phase separator failure; fluid in the phase separator exceeding a minimum volume indicates possible failure of the urine pump. The airflow sensor determines that the BMS is connected to the WCS and that the WCS is operational. Incorrect setting of user ID and sample container installed are the remaining two malfunction conditions indicated by a flashing condition of the COLL switch status light. Until corrected, these latter three malfunction conditions inhibit further system operation. If the malfunction indication persists, contingency operating procedures must be investigated.

Two use options are provided, a volume measurement and sampling option and a volume measurement only option. Actuation of either the PURG, SAMP and/or DUMP switches completes the user control inputs needed to complete a total use cycle. For the volume measurement only option, the DUMP switch is used (PURG and SAMP bypassed). In this use option, the system automatically measures the total micturition volume and flushes the system with water from the portable flush water tank. For the volume measurement and sampling option, a urine sample is also obtained.

## 3.0 OPERATING LIMITATIONS AND RESTRICTIONS

TBD

PART II-MISSION OPERATIONAL PROCEDURES

## 4.0 NORMAL PROCEDURES

### 4.1 Installation in SHUTTLE ORBITER

#### 4.1.1 Mechanical

a. TBD (BMS assembly, portable water reservoir, sample containers) location in SHUTTLE ORBITER and interconnected to WCS. Special tools, etc. TBD

#### 4.1.2 Electrical

a. TBD power/TLM cable connection(s) to TBD location(s) in SHUTTLE ORBITER and to WCS.

b. TBD ground cable connection between BMS and SHUTTLE ORBITER ground (TBD location).

### 4.2 Post Installation Checkout

The intent of post installation checkout is to verify successful BMS operation when installed in the SHUTTLE ORBITER. Checkout will consist of two activities, installation/interface verification and system test, as specified below.

#### 4.2.1 Installation/Interface Verification

a. Visually verify that each individual installation specified in 4.1 above has been accomplished.

b. Fill portable flush water reservoir by mating reservoir flex fill line quick disconnect with mating fuel cell water supply disconnect. Determine visually that tank is completely filled.

#### 4.2.2 Integrated System Test

##### 4.2.2.1 Power ON

a. Apply electrical power to BMS by actuation of PWR ON/CKT BKR switches.

4.2.2.2 Volume Measurement/Sampling Option

4.2.2.2.1 Collection Cycle

a. Verify that Purg, SAMP and DUMP switch actuation prior to COLL switch actuation will not cause BMS operation.

b. Start collection cycle by actuation of COLL switch.

c. Select representative user ID and apply to BMS via USER ID SEL switch.

d. Verify that COLL switch status light goes from flashing to full on condition. If flashing continues, a possible hardware malfunction is indicated; removal from the spacecraft for further testing may be required.

e. Verify that the WCS is operational.

f. Inject 500 ± 0.5 ml of ambient temperature potable water into the system via the urinal. Place urinal in stand-up position to prevent trapping fluid in the urinal hose. Input rate should be controlled (operator judgment) to less than 25 ml/second.

4.2.2.2.2 Purge Cycle

a. Initiate the purge cycle by actuation of the PURG switch.

b. Verify that PURG switch light activated to full on condition and COLL switch status light turned off.

c. At end of the purge cycle, verify that PURG switch status light off and SAMP switch status light activated to flashing condition.

4.2.2.2.3 Sampling Cycle

a. Connect sample container. Verify that SAMP switch status light does not go to full on condition until sample container in locked position and that sample container illumination lights are activated to full on condition.

b. Acquire sample by single or multiple actuations of SAMP switch.

c. Remove sample container. Verify that SAMP switch status and sample container illumination lights turned off and DUMP switch light is activated to flashing condition.

4.2.2.2.4 Dump Cycle

a. Initiate dump cycle by actuation of the DUMP switch. Verify that DUMP switch status light changed from flashing to full on condition.

b. Verify that micturition volume measurement data, user ID and sample container number transmitted to SHUTTLE ORBITER TLM.

c. Verify by calculation that volume measurement data is consistent with the 500 ml input and that user ID and sample container number were correctly determined by the system. NOTE: The system must contain a liquid residual from a recent test for accurate volume measurement results.

d. Verify that first urinal water flush occurs about 65 seconds (for 500 ml input) after initiation of dump cycle and that second urinal flush occurs about 40 seconds after completion of first flush input.

e. Verify that the DUMP switch status light out and WCS deactivated about 40 seconds after completion of second urinal water flush.

4.2.2.3 Volume Measurement Only Option

4.2.2.3.1 Collection Cycle

a. Start collection cycle by actuation of COLL switch.

b. Select representative user ID and apply to BMS via USER ID SELECT switch.

c. Inject 500 $\pm$ 0.5 ml of ambient temperature potable water into the system via the urinal. Place urinal in stand-up position to prevent trapping fluid in the urinal hose.

Input rate should be controlled (operator judgement) to less than 25 ml/second.

4.2.2.3.2 Dump Cycle

a. Initiate dump cycle by actuation of DUMP switch. Verify that DUMP switch light activated to full on condition and that COLL switch status light off.

b. Verify that volume measurement data, user ID and sample container not installed code transmitted to SHUTTLE ORBITER TLM.

c. Verify that volume measurement data, user ID and sample container number (not installed code) were correctly determined by the system.

d. Verify initiation and completion of the automatic flush cycle as in 4.2.2.2.4 (d) and (e) above.

e. Remove electrical power from system by actuation of PWR ON/CKT BKR switch. Verify that switch status lights off.

4.3 Inflight Operation

4.3.1 Power ON

a. At start of mission operations, apply power to BMS by actuation of PWR ON/CKT BKR switch. For normal conditions, leave power ON for mission duration.

4.3.2 Volume Measurement/Sampling Option

a. Actuate COLL switch.

b. Set user ID via USER ID SEL switch.

c. Position urinal (either stand-up or sit-down position).

d. Micturate.

e. Replace urinal.

f. Actuate PURG switch

g. When SAMP switch status light activated to flashing condition, install sample container (translation plus rotation to lock in place).

h. Fill sample container to "level" desired by single or multiple actuations of SAMP switch.

i. Remove sample container, cap needle end and return to storage.

j. Actuate DUMP switch.

4.3.3 Volume Measurement Only Option

a. Actuate COLL switch.

b. Set user ID via USER ID SEL switch.

c. Position urinal (either stand-up or sit-down position).

d. Micturate.

e. Replace urinal.

f. Actuate DUMP switch.

4.3.4 Flush Water Reservoir Refill

a. At approximate 24 hour intervals, refill the portable flush water reservoir using the following procedure.

1. Disconnect the reservoir flex line quick disconnect (from the BMS structure.

2. Mate the flex line quick disconnect to the fuel cell water supply, located TBD.

3. Visually verify that the tank is completely filled.

4. Disconnect from the fuel cell supply and reconnect to the BMS.

### 4.3.5 Sample Container Removal

Depending on several factors, a residual pressure build-up within the sample container may occur when a sample is obtained. Thus, each sample container should be removed from the sampling port in two steps as follows.

a. Rotate and withdraw the sample container about 0.1 inches; hold in this position for about 5 seconds. This allows any residual pressure to vent back into the sampling assembly instead of externally.

b. Complete withdrawal of the sampling container and recap the needle tip end.

## 5.0 CONTINGENCY PROCEDURES

During inflight operation of the BMS, an event or combination of events effecting the performance of the BMS may occur. Depending on the event, subsequent inflight operation at a reduced performance level or complete shut-down of the BMS may be required. Power failure, BMS component failure and/or user error are examples of these events. These events and contingency operating procedures to minimize their impact are discussed below.

### 5.1 Input Power

Momentary (or sustained) interruption of input electrical power to the BMS during BMS operation will terminate further system operation. The system logic elements will reset to their "zero" condition, i.e., system ready for next user; as a consequence, both BMS and WCS hardware elements will be deactivated.

External evidence of this condition will be signaled by:

a. no airflow into the urinal.

b. no airflow blower noise.

c. all control switch status lights out.

The following contingency procedure is recommended:

a. When power is restored, proceed normally by actuation of the COLL switch followed by inserting user ID via the USER ID SEL switch. This will start both the BMS and WCS and permit initiation of further system functions.

b. If a sample is desired, proceed directly and normally thru the PURG, install sample container, SAMP, remove sample container, DUMP routine. If no sample is required (or had already been acquired) go direct to DUMP.

This contingency procedure will assure that the system has been emptied and flushed and consequently ready for the next user. Note that urine and/or flush water will remain trapped in the BMS during the shut-down period and this will not constitute a hazard to the spacecraft or crew(fluid retention is due to a combination of surface tension forces and equipment geometry). However, if loss of power occurs prior to volume measurement, a significant measurement error may result. This is due to possible loss of fluid from the BMS to the WCS during initial start-up after power is restored.

5.2 Equipment Malfunction

Malfunction of either BMS or WCS equipment may prevent implementing the various system cycles. Depending on the location of the malfunction, the following contingency operating procedures are recommended.

5.2.1 Urine Collection

a. WCS Malfunction

Failure of the WCS phase separator, blower, or urine pump (or the associated controls) can prevent effective urine collection by the BMS. Evidence of WCS failure will be signaled by both the BMS and WCS control panel displays and, if blower failure, loss of airflow and lack of blower noise. In this situation, follow appropriate WCS emergency operating procedures.

b. BMS Malfunction

Failure of the BMS phase separator or urine pump (or associated control logic) can prevent effective urine collection by the BMS. Evidence of this type malfunction will be continued flashing of the COLL switch status light. In this situation (and without micturating) proceed directly to DUMP. After completion of the DUMP cycle, restart the system by actuation of the COLL switch.

If abnormal flashing of the COLL switch status light continues, disconnect the BMS and use the WCS for the remainder of the mission.

5.2.2 PURGE

a. Cycle Malfunction

Failure of the urine pump, solenoid valve or associated control logic can prevent effective purge action. Possible failure may be evidenced visually by lack of status light indication when PURG switch is actuated or by a continued ON status indication (for more than 1.6 seconds) coupled with an acoustic indication of urine pump action (or lack thereof).

If the purge cycle will not start (no status light or pump noise), use the DUMP switch to control purging manually. In place of actuating the PURG switch, actuate the DUMP switch and in about 2 seconds actuate the COLL switch to stop the pump action. This action duplicates the automatic purge cycle.

If the purge cycle does not terminate automatically in 1.6 seconds, stop the purge action by reactivating the COLL switch.

Since failure of the purge cycle normally will inhibit the sampling cycle, obtain a sample by activating the DUMP switch to start the urine pump and immediately install a sample container. Stop sampling action by reactivating COLL switch; remove sample container and reactivate DUMP switch to complete cycle.

5.2.3 Sampling

a. Container Installation Malfunction

Translation and rotation is required to properly position the sample container in the sampling assembly. If the container is incorrectly

installed or the container position markers are missing or incorrectly located, electronic verification of sample container connection to the sampling port and readout of sample container number cannot be accomplished. The SAMP switch status light will continue flashing as evidence of lack of connection verification. Correct by removal and reinstalling the sample container or by replacing with an alternate container. If correction verification still cannot be achieved (SAMP switch status light remains in flashing condition), proceed as in (b) below or remove the sample container, and go directly to the dump cycle (without obtaining a sample).

b. Cycle Malfunction

Failure of the urine pump, solenoid valve or associated electronics can prevent filling of the sample container. Both visual (sample container does not fill) and/or acoustic (no pump noise) indications will denote this type malfunction.

If the purge cycle operated normally, a sample may be obtained by actuation of the DUMP switch rather than the SAMP switch. In this mode, sample size may be controlled by using the COLL switch to stop the urine pump action.

5.2.4 Dump

a. Failure of urine pump, solenoid valve and associated control logic can prevent the urine remaining in the phase separator from being dumped to the WCS for disposal. Evidence of this type failure will be indicated by continued operation of the system coupled with possible lack of pump noise. Thus the system will not automatically shut off (maximum normal dump cycle time is about 3 minutes). Terminate dump cycle operation by activation of the COLL switch and then reactivation of the DUMP switch. If automatic shut-off still does not occur, terminate system operation via the PWR ON/CKT BKR switches, disconnect the BMS from the WCS and use the WCS for the remainder of the mission.

5.2.5 Flush

Failure of the flush portion of the dump cycle may be determined by visual inspection of the urinal during the dump cycle. Failure of the flush equipments will not prevent completion of the dump cycle and therefore will not be automatically brought to the attention of the user. After verifying that the portable flush water reservoir is filled and properly connected, request instructions regarding the collection of further urine samples.

5.3 User Error

Since each system operating cycle (except flush) is manually initiated by the user, inadvertant improper sequencing may occur. If desired, this user sequencing error may be corrected by reactivation of the COLL switch followed by activation of the PURG or DUMP switches as desired. Note that sampling must be preceded by a purge cycle.

## 5.4 Sample Container ID

A liquid droplet or film covering the sample container ID sensors located in the sampling assembly can result in an incorrect container ID or indicate (incorrectly) to the system that a sample container is installed. In this latter instance, the sampling assembly illumination lights will be activated and the COLL switch indicator light will be flashing. This condition may be caused by septum leakage or incorrect removal of the sample container (see 4.3.5). In either case, the liquid must be removed from the sensors before further system operation can occur. A soft absorbant material is suitable for this purpose. If the septum is leaking, replacement of the septum may be readily accomplished using the special tool provided.

## PART III-GROUND OPERATING AND MAINTENANCE PROCEDURES

6.0 PRELAUNCH PROCEDURES

Prelaunch procedures as specified below, shall be accomplished at the launch site prior to installation in the SHUTTLE ORBITER.

6.1 Receiving Inspection

Upon receipt of flight hardware at the launch site, identify and verify completeness of material received based on accompanying documentation. Also, perform a visual inspection for possible shipping and handling damage.

7.0 POST RECOVERY PROCEDURES

Post recovery test and maintenance, as noted below, shall be accomplished at the suppliers manufacturing facility or other facility as specified by NASA.

7.1 Receiving Inspection

Verify completeness of material received and perform a visual inspection for possible damage due to flight operations and subsequent post recovery operations.

7.2 System Test

Using suitable test equipment, determine operability of the system by performing a system test using the same procedure as specified in Part II, Section 4.2.2 of this document but with the following exception: Substitute a disinfectant solution (type TBD) for the potable water used during the collection cycle.

7.3 Refurbishment

Normal between mission maintenance shall be performed after each mission as specified below (personnel shall be suitably protected[1]).

[1] Appropriate techniques are required during disassembly, component handling and cleaning and reassembly to preclude microbiological contamination.

a. Disassemble the system, i.e. remove those components in the fluid loop.

b. Remove and dispose of the silica gel dryer.

c. Disinfect, clean and inspect the fluid loop components (for signs of excessive wear or other possible failure modes).

d. Replace elastomer seals and silica gel dryer.

e. Check operability of fluid loop components via performance testing.

f. Reassemble system.

g. Using suitable test equipment, verify system operation using the same procedure as specified in Part II, section 4.2.2 of this document.

h. Check calibration and recalibrate is necessary.

7.4 Failure Analysis

7.4.1 General

In addition to the system external visual and/or audible indications of the cause of system malfunction, a test connector is provided ( located on electronics box adjacent to sampling assembly) for monitoring the pressure sensor output as a further means of failure analysis (and for BMS calibration). Measurement data and WCS control signal validity may be determined via the available TLM output connector.

8.0 OPERATING LOG

TBD (record all tests, maintenance performed, inspection results, etc.)

## PART IV - APPENDIX

### 9.0 SYSTEM OPERATING SEQUENCE

REF: BMS Block Diagram and Control/Display Panel Layout

### 1.0 POWER ON

1.1. Both POWER ON/CIRCUIT BREAKER switches actuated at start of mission operations.

1.2 Power from SHUTTLE applied to system.

### 2.0 COLLECTION CYCLE

2.1 User actuates COLL switch. Actuating COLL switch applies electrical power to system hardware (phase separator, internal power supply, sensors and control logic) and simultaneously actuates WCS.

NOTE: No action if PURG, SAMP, or DUMP switches actuated before COLL switch. Also the COLL switch, at user option, may be actuated at any time during a purge, sampling, or dump cycle to override these functions. This action immediately returns the system to collection cycle operation.

2.2 COLL switch status light activated to flashing condition until satisfactory operating status check (2.4 below) completed by programmer.

2.3 User positions USER ID SEL switch via reset position.

2.4 Operating Status Check (Self-monitor).

2.4.1 Airflow sensor verifies minimum transport airflow condition exists. If below minimum airflow, COLL switch status light is held in the flashing condition and further system operation inhibited.

2.4.2 Sample container position sensor verifies sample container not installed and thus dump line open to WCS from urine pump. If sample container installed, COLL switch status light remains in the flashing condition and system operation inhibited.

2.4.3 To minimize user ID error, the USER ID SEL switch must be returned to RSET position before setting to user ID position. If this sequence is not followed, the COLL switch status light remains in the flashing condition and further system operation inhibited.

2.4.4 Phase separator RPM SENSOR indicates minimum rpm achieved and therefore phase separator is operating properly. If below minimum rpm, COL switch status light stays in flashing condition; further system operation is <u>not</u> inhibited.

2.4.5 Phase separator PRESSURE SENSOR indicates fluid residual volume in phase separator below a minimum level and therefore capable of accepting a maximum volume micturition. If fluid minimum residual volume exceeded, COLL switch status light remains in flashing condition; further system operation is <u>not</u> inhibited.

2.4.6 If conditions causing the COLL switch status light flashing state cannot be corrected, instigate contingency operating procedures.

2.5 Assuming operating status is GO, i.e., WCS and phase separator operational, the user properly identified and sample container not installed, COLL switch status light activated from flashing condition to solid (full on) condition.

2.6 <u>User</u> positions urinal (seated or standing position optional).

2.7 <u>User</u> micturates.

2.8 Urine conveyed into phase separator by transport airflow; transport air rejected to WCS concurrently with micturition.

2.9 User returns urinal to stowed position.

3.0 VOLUME MEASUREMENT/SAMPLING OPTION

3.1 PURGE CYCLE

3.1.1 User actuates PURG switch.

3.1.2 PURG switch status light activated to full-on condition and COLL switch status light off.

3.1.3 Store volume measurement data for subsequent dump to TLM. Start urine pump and energize solenoid valve SV; operate for fixed time period (1.6 seconds) to pump approximately 15 ml of urine from the phase separator. This action replaces the residual liquid in the pump and associated plumbing with urine.

3.1.4 Stop urine pump and deengergize valve SV. PURG switch status light off, SAMP switch status light activated to flashing condition.

3.2 SAMPLING CYCLE

3.2.1 User connects sample container to sampling port. This action blocks urine flow to dump.

3.2.2 Verify engagement of sampling container (locked position) with sampling port. At verification, activate SAMP switch status light to full on condition. Also activate sample container illumination lights to full on condition.

3.2.3 If verification of sample container connection to sampling port cannot be obtained, inhibit the sampling sequence (3.2.4 below). Remove sample container and override sequence by user initiation of dump cycle (4.0 below).

3.2.4 Acquire sample by user operation of SAMP switch. Closing of SAMP switch starts urine pump and energize valve SV; urine pump stopped and valve SV deenergize when switch closure terminated by user. This on-off pump control may be repeated as desired by the user until the sample container is filled with the desired quantity of urine (as determined by visual observation of the sample container by the user).

NOTE: SAMP switch action inhibited until purge cycle (3.1) has been completed.

3.2.5 On first SAMP switch closure (3.2.4 above), store User ID and sample container number for subsequent dump to TLM.

3.2.6 User removes sample container. At removal verification, SAMP switch status light and sample container illumination lights deactivated to off condition; DUMP switch status light activated to flashing condition.

3.3 DUMP CYCLE

3.3.1 User actuates DUMP switch; DUMP switch status light activated from flashing to full on condition.

NOTE: If sample container has not been removed, DUMP switch status light remains in flashing condition.

3.3.2 Start urine pump and energize solenoid valve SV to empty phase separator to dump. Continue operation for 25.6 seconds after volume in phase separator reduced to about 40 ml (as determined by the pressure sensor).

3.3.3 When urine pump off and valve SV deenergized, energize flush water pump, injecting flush water from the portable tank into the system via the urinal.

3.3.4 On flush pump actuation, send volume measurement data, User ID and sample container number to SHUTTLE ORBITER TLM interface.

3.3.5 Operate the flush water pump for 3.2 seconds (until about 60 ml of flush water has been injected into the system).

3.3.6 After a 6.4 second delay, operate urine pump and energize valve SV for 33.6 seconds.

3.3.7 Repeat 3.3.4 thru 3.3.6.

3.3.8 DUMP switch status light out and WCS, phase separator, etc., deactivated.

3.3.9 System ready for next user.

## 4.0 VOLUME MEASUREMENT ONLY OPTION

### 4.1 DUMP CYCLE

4.1.1 User actuates DUMP switch; DUMP switch light activated to full-on condition and COLL switch status light off.

4.1.2 On DUMP switch actuation, volume measurement data and User ID stored and sent to SHUTTLE ORBITER TLM interface as in 3.3.4 above. Also indicate no sample container by 0000 number code.

4.1.3 Same as 3.3.2

4.1.4 Same as 3.3.3

4.1.5 Same as 3.3.5.

4.1.6 Same as 3.3.6.

4.1.7 Same as 3.3.7.

4.1.8 Same as 3.3.8.

4.1.9 System ready for next user.

## 10.0 DRAWING LIST

| | |
|---|---|
| BMS Assembly | ER 47E231825* |
| Phase Separator Assembly | ER 47D231800 |
| Housing, Inlet Side | ER 47D231801 |
| Housing, Motor Side | ER 47D231802 |
| Impeller | ER 47D231803 |
| Basket | ER 47C231804 |
| Screen | ER 47B231805 |
| Detail, "O" Ring | ER 47C231806 |
| Motor | ER 47C231807 |
| Shaft | ER 47C231816 |
| Shim | ER 47C231819 |
| Bag Assembly Silica Gel | ER 47C231822 |
| Exhaust | ER 47C231841 |
| RPM Sensor Assembly | ER 47B231915 |
| Bracket | ER 47C231911 |
| Shim | ER 47B231912 |
| Air Flow Sensor Assembly | ER 47D231917 |
| PC Board D and T | ER 47D231918 |
| Plate | ER 47D231919 |
| Sensor Bracket #1 | ER 47D231920 |
| Sensor Bracket #2 | ER 47D231921 |

* Enclosed

DRAWING LIST (Continued)

| | |
|---|---|
| Transformer Output | ER 47D231895 |
| Transformer, Saturable | ER 47D231894 |
| Power Convert D and T | ER 47D231880 |
| Wire List | ER 47A231878 |
| Interconnect Diagram | ER 47J231879* |
| PWB Assembly A2, A/D Convert | ER 47D231892 |
| A/D Convert, D and T | ER 47D231882 |
| A/D Convert, Schematic | ER 47J231877 |
| PWB Assembly A1, Control Logic | ER 47D231891 |
| Control Logic, D and T | ER 47D231881 |
| Control Logic, Schematic | ER 47J231876 |
| Sample Container | ER 47C231808 |
| Pressure Transducer | ER 47C231818 |
| Flange, Prem. Transducer | ER 47C231821 |
| Pump, Gear | ER 47C231824 |
| Valve Support | ER 47B231843 |
| Cover, Front | ER 47D231826 |
| Cover, Aft | ER 47D231837 |
| Adapter, Air Return | ER 47D231837 |
| Details | ER 47D231821 |
| Magnetics, Gen. Notes | ER 47A231914 |
| Matched Diodes, Pwr Supply | ER 47A231922 |
| Selected Resistor, Pwr Supply | ER 47A231923 |

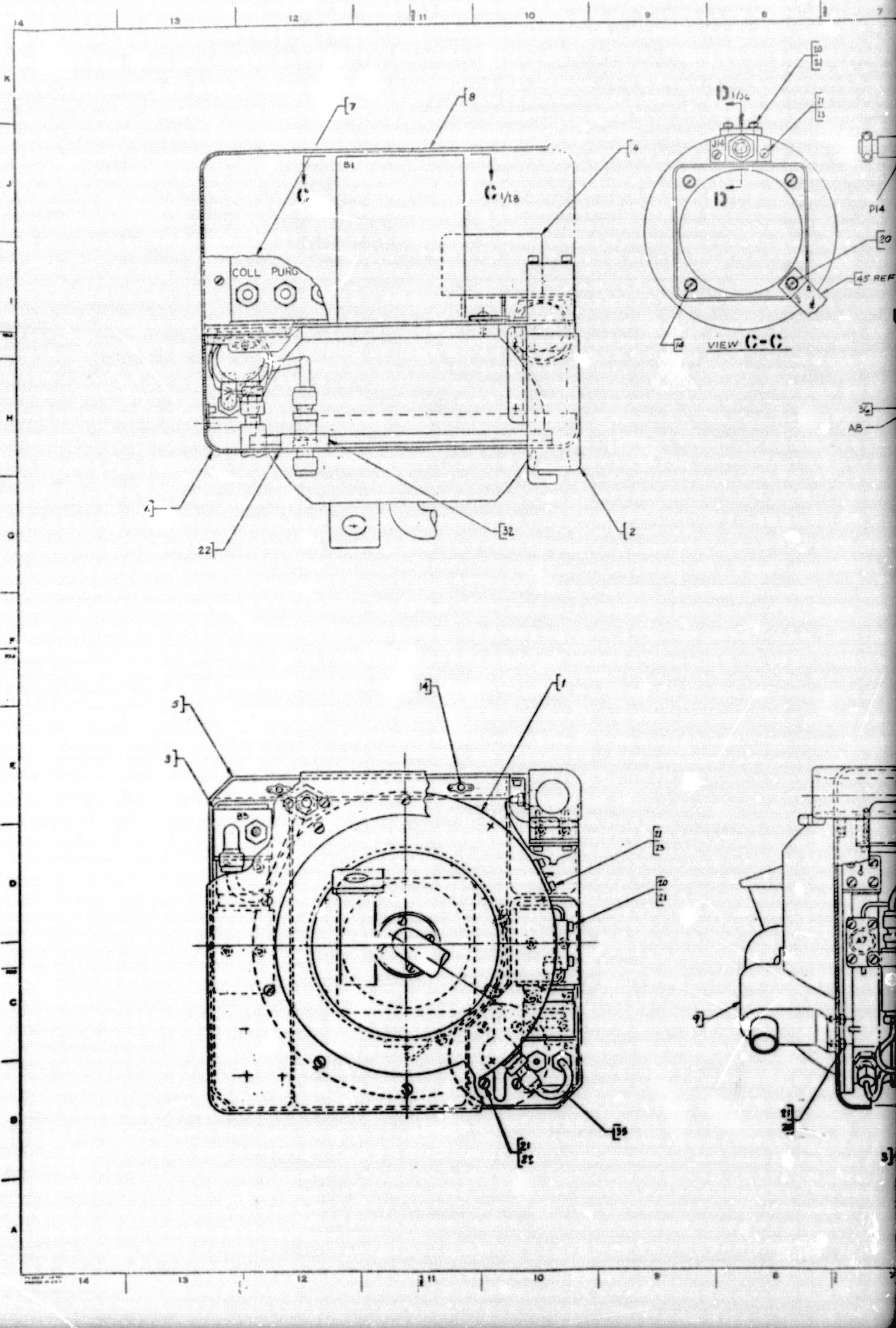
* Enclosed

## DRAWING LIST (Continued)

| | |
|---|---|
| Sampling Port | ER 47D231810 |
| Housing, Sample Container | ER 47C231809 |
| Housing Septum | ER 47C231811 |
| Housing, Sample Bypass | ER 47C231812 |
| Bracket, Support | ER 47C231820 |
| Septum | ER 47C231823 |
| Sampling Port Sensor Assembly | ER 47D231900 |
| Housing | ER 47C231901 |
| Shaft | ER 47B231902 |
| Nut | ER 47A231903 |
| Shim | ER 47B231904 |
| PC Board Assembly | ER 47D231905 |
| PC Board D and T | ER 47D231906 |
| Cable Clamp | ER 47D231907 |
| Urinal Assembly | ER 47D231840 |
| Funnel | ER 47C231838 |
| Cap | ER 47C231839 |
| Flush Water | ER 47C231846 |
| Connector | ER 47C231844 |
| Connector | ER 47C231845 |
| Tank Assembly | ER 47D231828 |
| Tank | ER 47D231829 |
| Bladder | ER 47D231830 |

## DRAWING LIST (Continued)

| | |
|---|---|
| Tank Assembly (Continued) | |
| Stand Pipe | ER 47D231833 |
| Nut | ER 47C231831 |
| Filter | ER 47B231832 |
| Piping | ER 47C231836 |
| Hose | ER 47C231834 |
| Fitting | ER 47C231842 |
| Tubing Det. | ER 47C231817 |
| Control Box Assembly | ER 47E231924 |
| Cover Assembly | ER 47C231883 |
| Bezel Assembly | ER 47E231889 |
| Plate, Control Panel | ER 47D231893 |
| Container Assembly | ER 47E231888 |
| Guard, Switch | ER 47E231887 |
| Diode Board Assembly | ER 47C231910 |
| Power Supply Assembly | ER 47D231886 |
| Bracket Assembly | ER 47D231899 |
| Bracket, Filter | ER 47D231885 |
| Choke, Input | ER 47D231898 |
| Schematic | ER 47D231875 |
| PBW Assembly A3, Pwr Convert | ER 47D231890 |
| Choke, ± 15 V Output | ER 47D231897 |
| Choke, + 5V/+22 V Output | ER 47D231896 |

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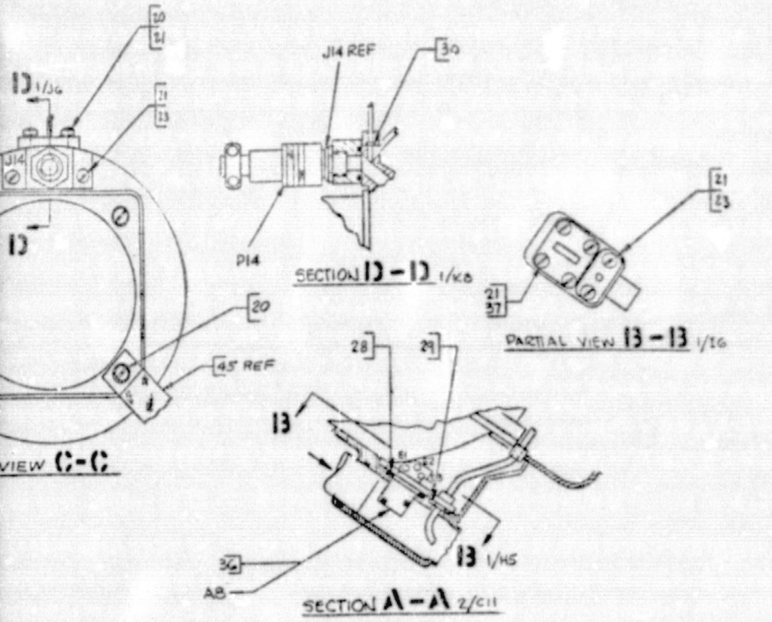



NOTES:

1-INTERPRETATION OF DRAWING TERMS AND TOLERANCES PER S30009

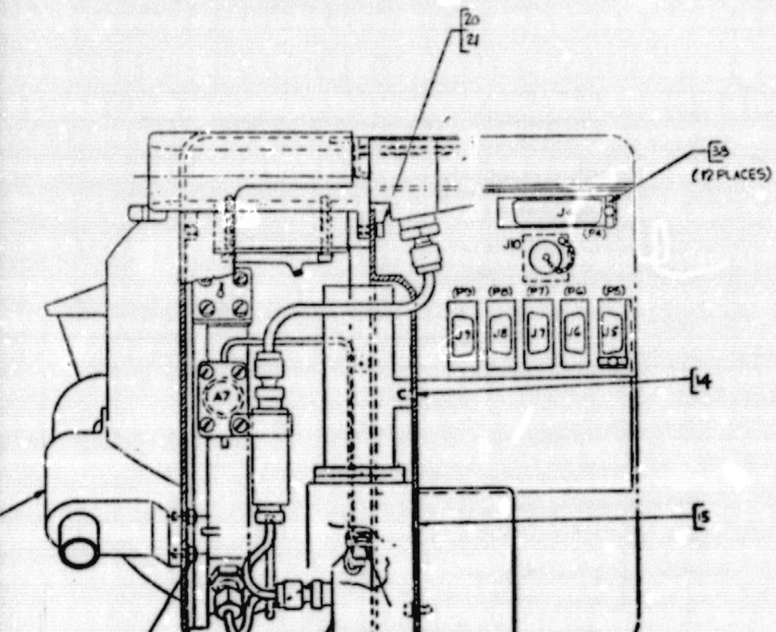
2-MARK "23991-ER47E231825G_PER 118A1526

3-TORQUE REQUIREMENTS:

| THREAD SIZE | |
|---|---|
| #4-40UNC | 5-6 IN LBS |
| #6-32UNC | 7-8 IN LBS |

4-MARK REFERENCE DESIGNATIONS PER 118A1526 APPROX AS SHOWN, REF DES IN PARENTHESIS ( ) ARE SHOWN FOR REFERENCE ONLY.

5-FOR ELECTRICAL CONNECTIONS SEE WIRE LIST, ITEM 39. WIRE PER S300142/6.

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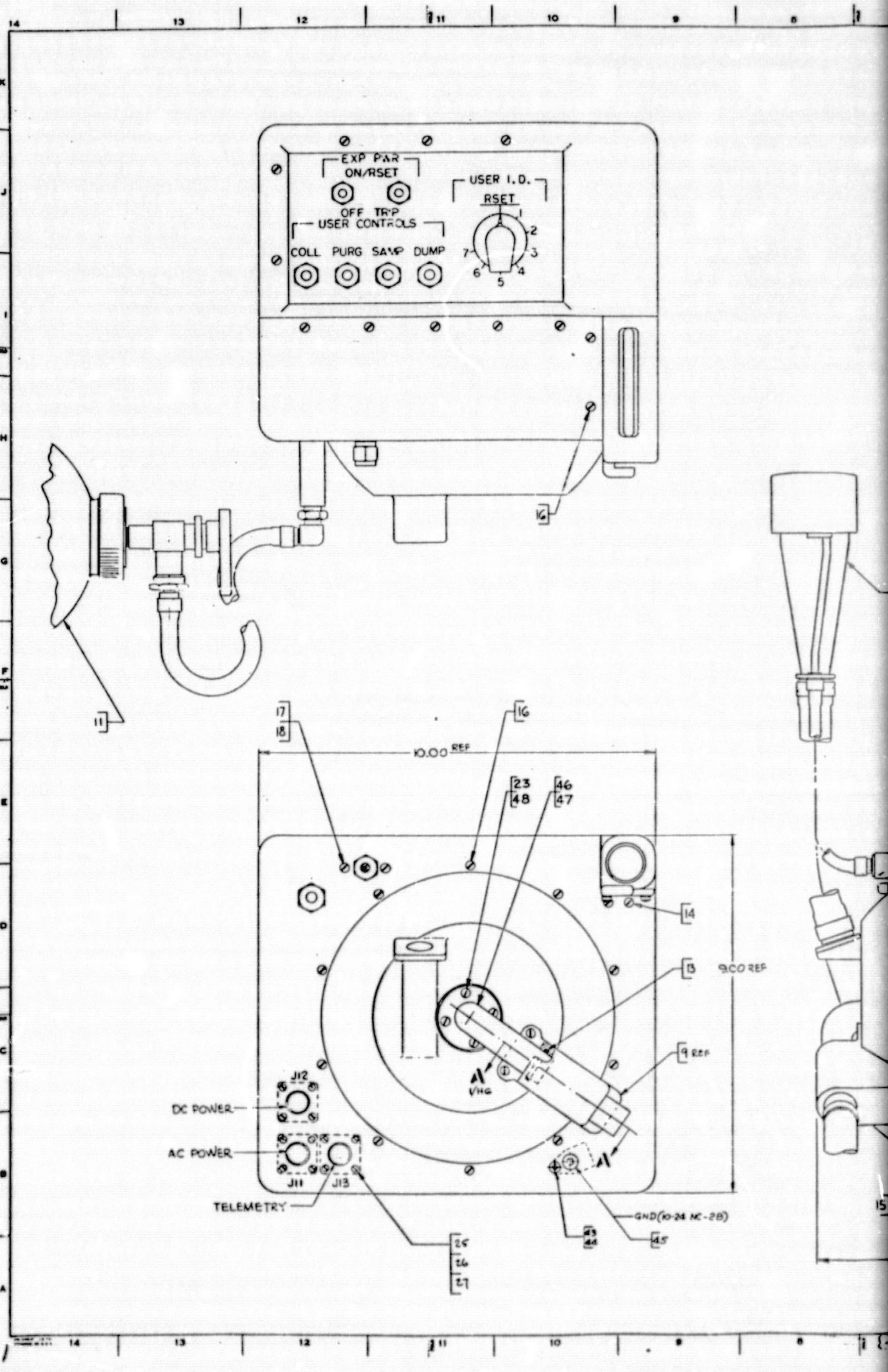
ORBITER BIOWASTE MONITORING SYSTEM

SIZE E | CODE IDENT NO. 23991 | ER47E231825

SHEET 1 OF 2



FOLDOUT FRAME 2

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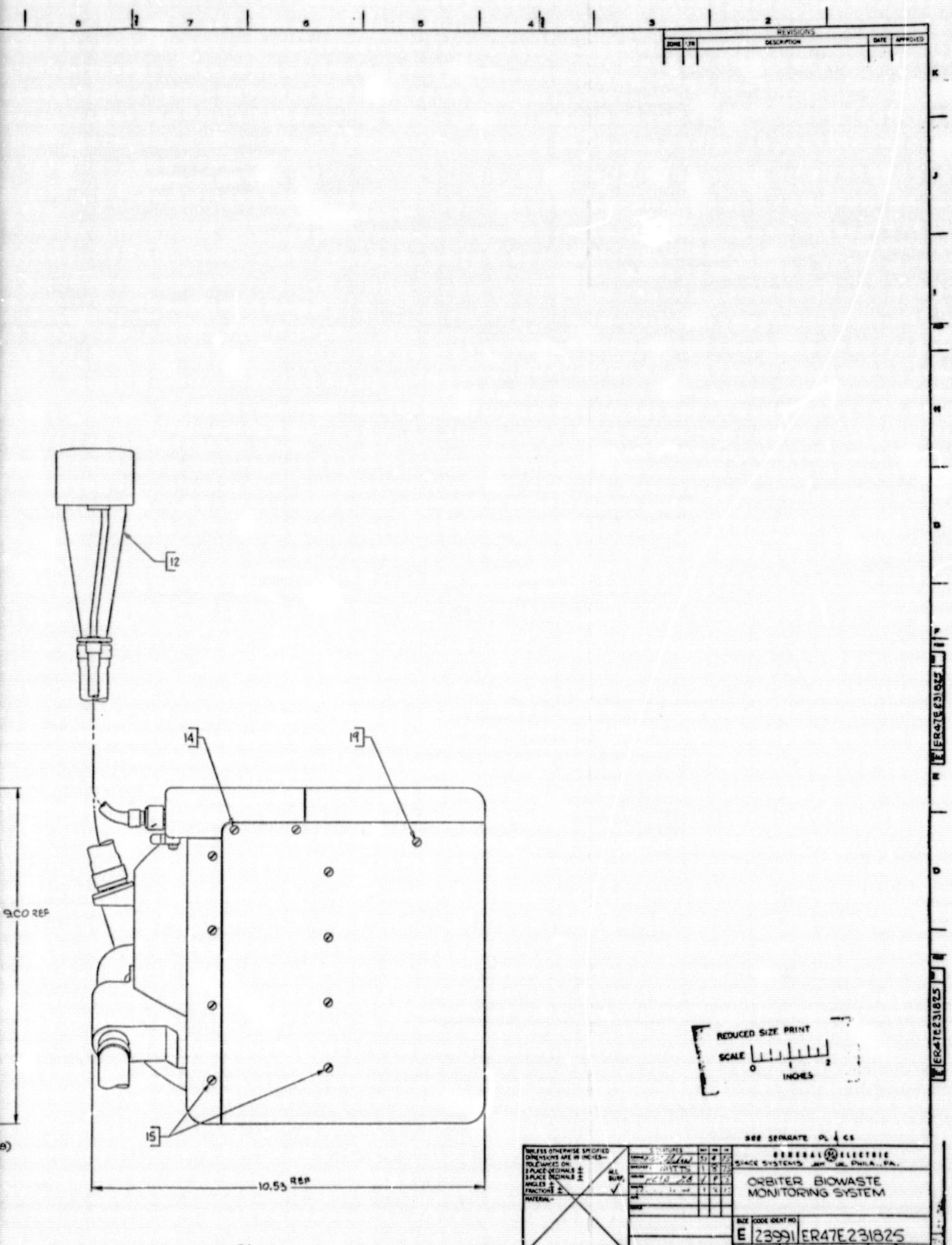




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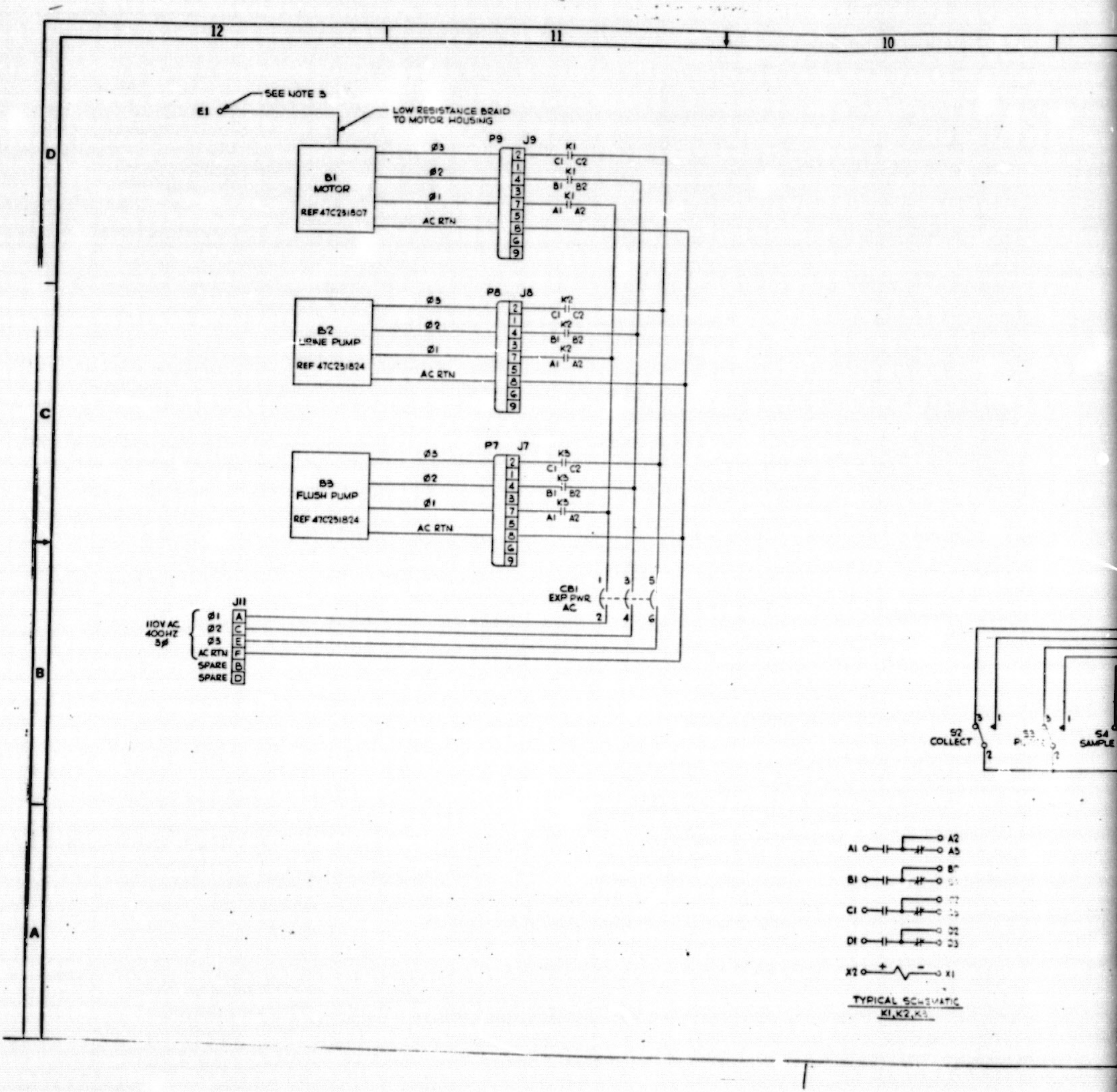


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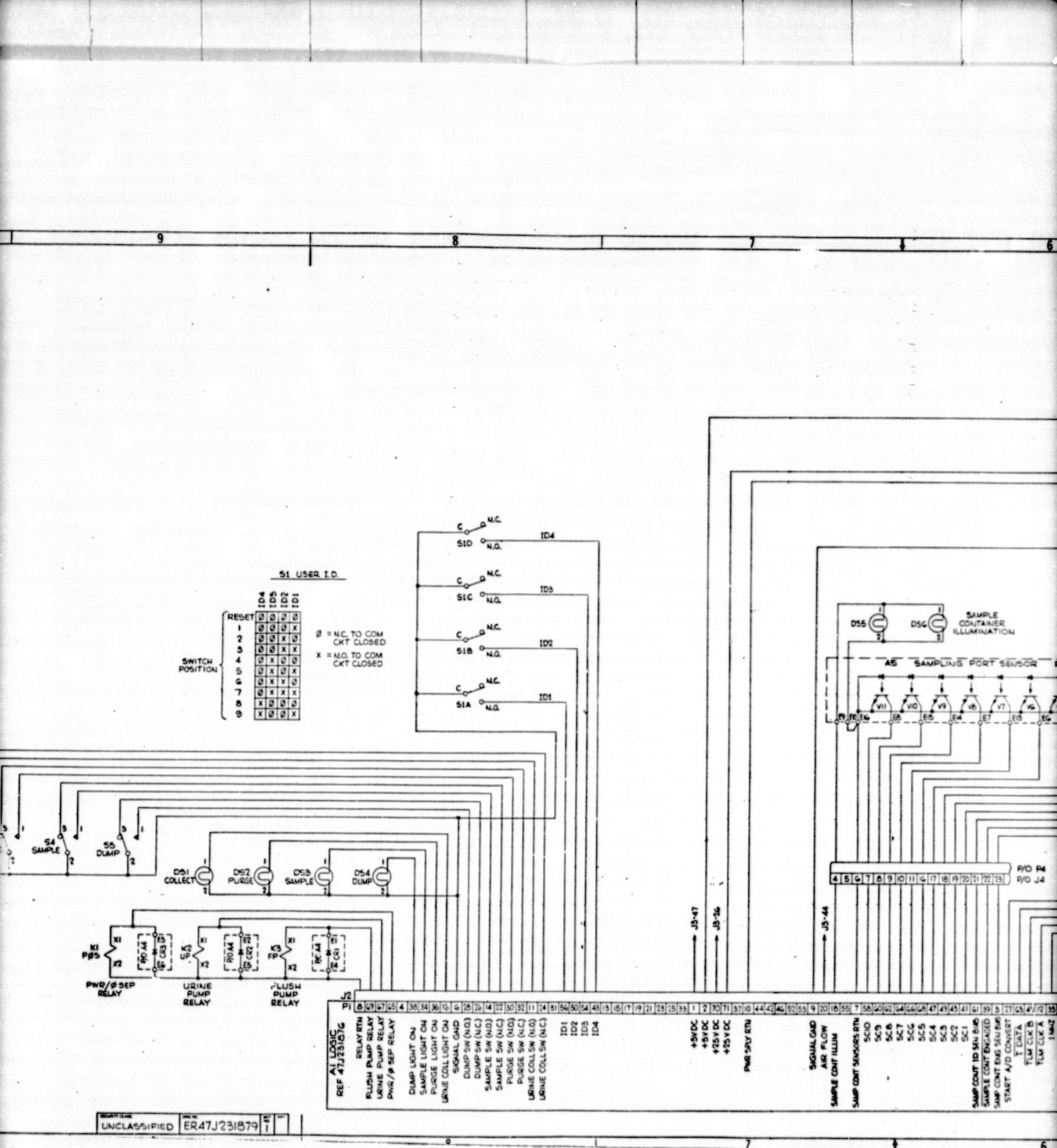


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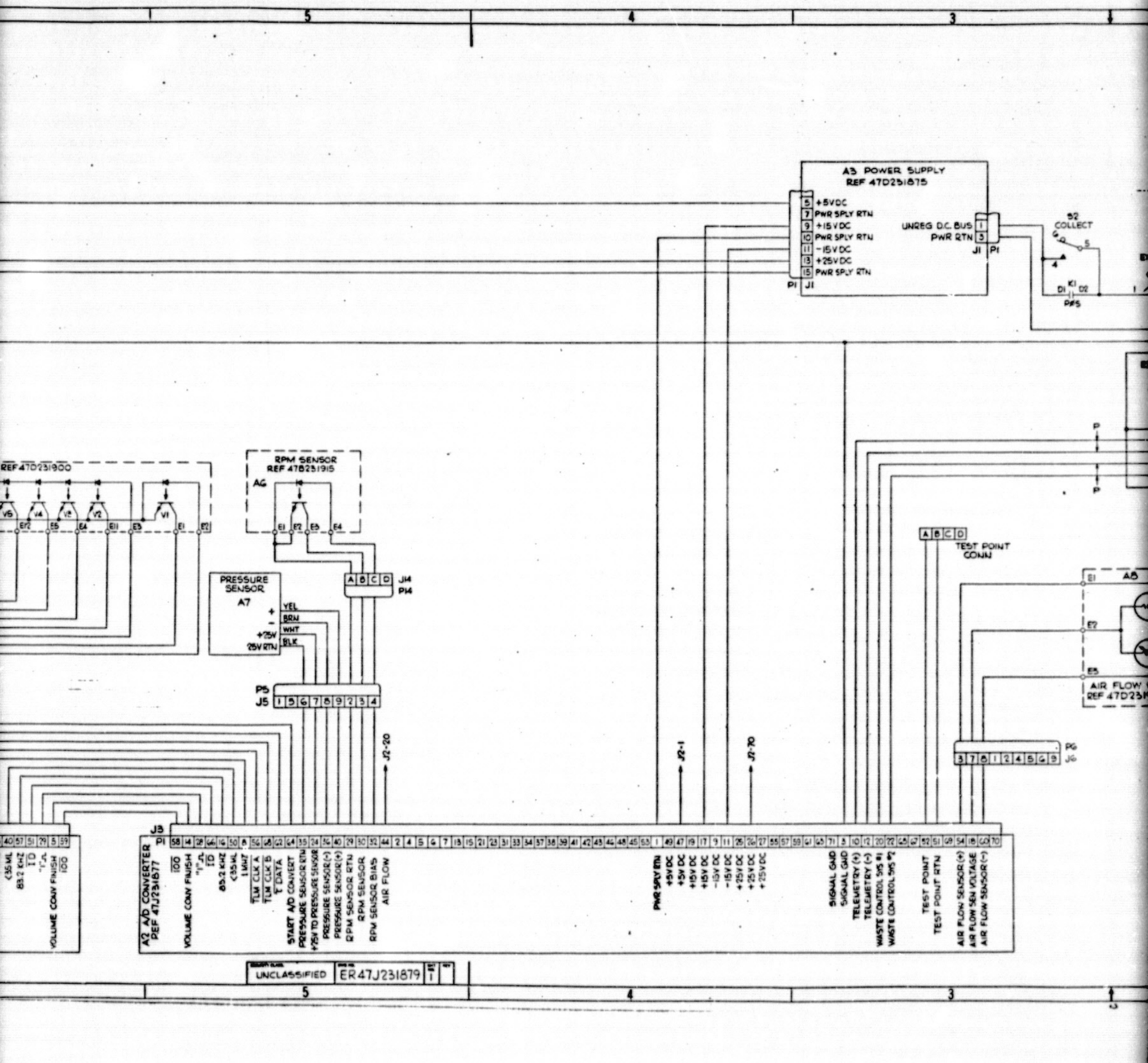
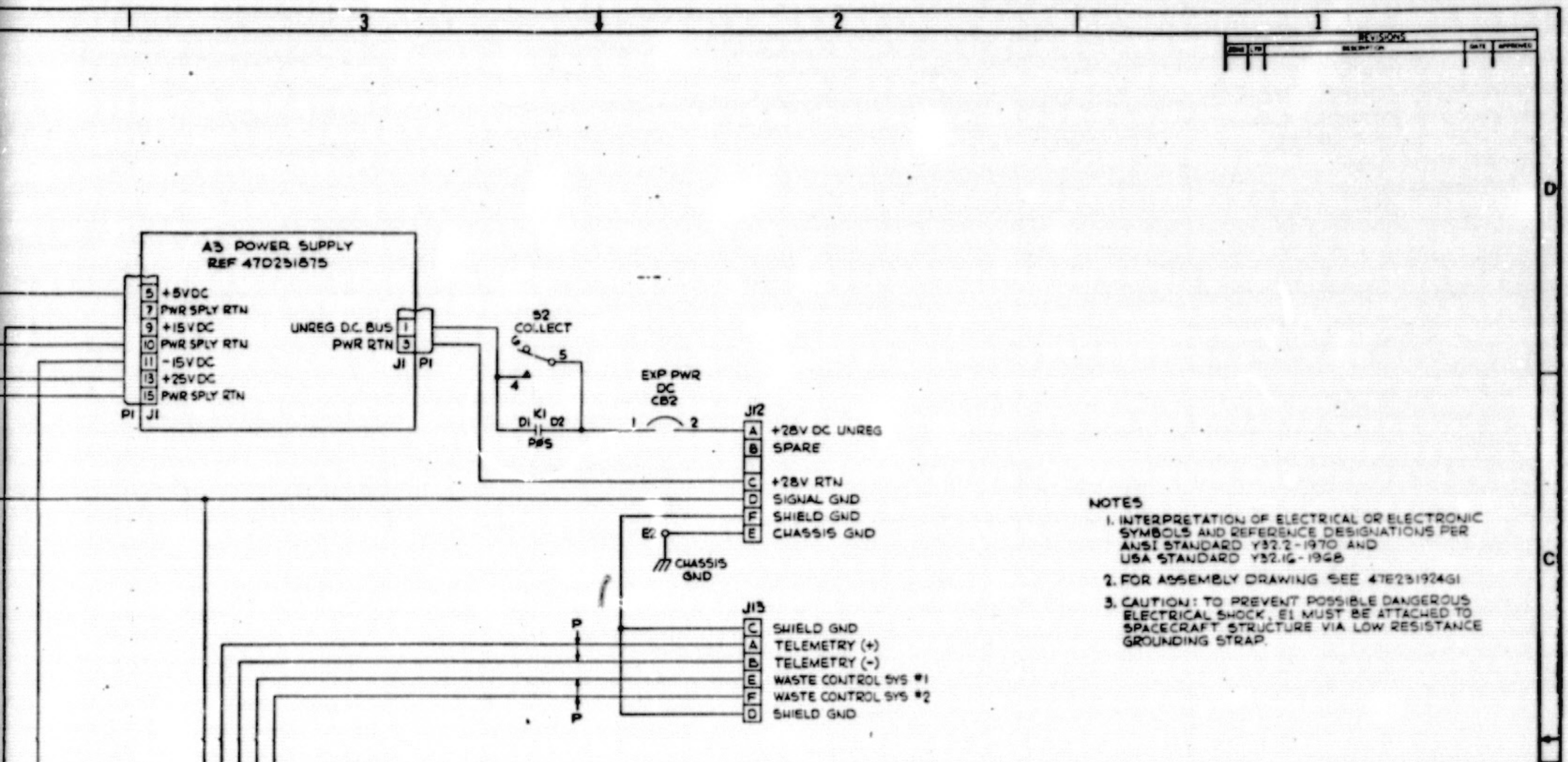



FOLDOUT FRAME 3



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## 11.0 MISCELLANEOUS

### 11.1 TLM Output Interpretation

Three words are transmitted by the BMS electronics via the telemetry output. These words contain sync, 16 bits of data, and one parity bit. They are transmitted in a Manchester II code to the s/c telemetry system.

Word 1 consists of two logic "1" data bits, followed by a ten-bit binary number ($S_{10} \rightarrow S_1$) respresenting the sample container number, followed by a four-bit binary number($I_4 \rightarrow I_1$) representing the user ID.

For example, if $S_{10}$ and $S_1$ were a "1" and $S_9$ through $S_2$ were "0", this would indicate that sample container 513 had been used to collect the urine sample. Similarly, if $I_3$ were a "1" and $I_4$, $I_2$, and $I_1$ were "0", this would indicate that the sample was from User 4.

Word 2 consists of a 12-bit binary word representing the rotational period of the motor ($\tau_{12} \rightarrow \tau_1$) followed by four zeros. Thus, the decimal equivalent of this binary word, $\tau$, is a number ranging from 0 to 4096. To obtain the period in seconds, multiply by 48 X $10^{-6}$. For example, if $\tau$ equals 4096, the period is .19661 seconds corresponding to a rate of 60/.19661 or 305 rpm. Similarly, for $\tau$ = 3072, the period is .14746 seconds corresponding to 406.9 rpm.

Word 3 consists of a 12-bit binary word representing the pressure ($P_{12} \rightarrow P_1$) followed by four unused bits. The pressure reading may be interpreted as follows. The buffered pressure transducer voltage, V, is presented to the A/D converter. This voltage, as seen at the test connector, is adjusted so that the range of interest lies between 0 to +10 volts. The voltage read by the A/D converter is the decimal equivalent of $P_{12} \rightarrow P_1$ (P) times 10 volts,

divided by 4096, or $V = P/409.6$. Thus for $P = 4096$ the pressure transducer output voltage is $V = \frac{4096}{409.6} = 10$ volts. For $P = 2048$, the corresponding voltage is 5 volts.

### 11.2 Pressure Sensor Adjustment

Offset and gain adjustments are located as shown in Figure 11-1.

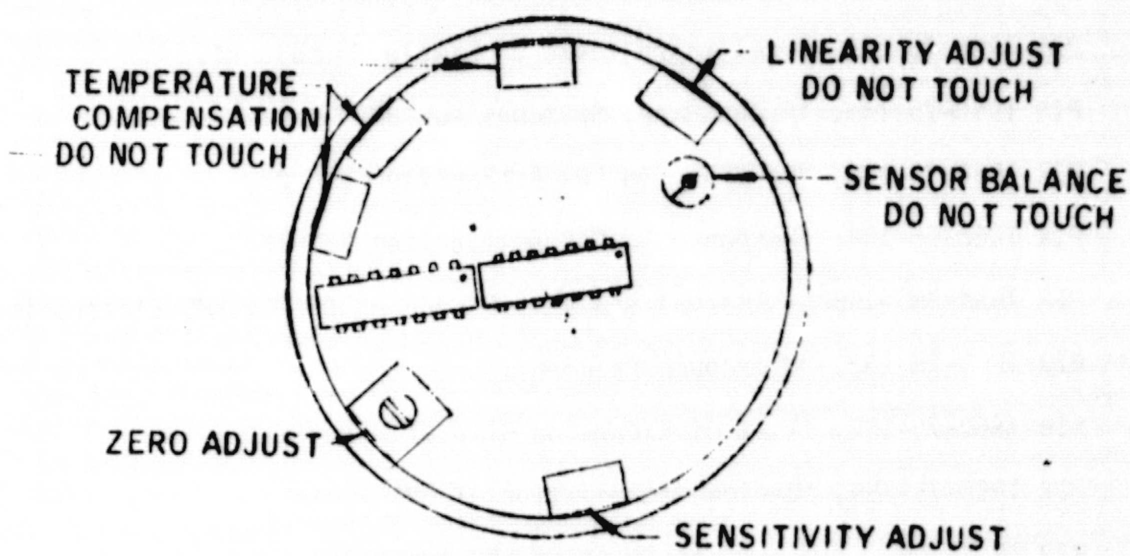


FIGURE 11-1 ADJUSTMENT LOCATIONS

11.3 Airflow Sensor Adjustment

The airflow sensor adjustment pots are located as shown in Figure 2-9(b). Normally, the 5K pot should be used.

## 6.2 Supplemental Design Information

The following GE internal memos and vendor data are intended to supplement/update previous design information contained in the interim, PDR and/or CDR reports:

PIR 1R60-75-208, "Prelimnary Tests On Sample Container".

PIR 1R60-75-143, "Front Panel Switches For BMS".

PIR 1R60-75-144, "Response To CDR Action Item No. 2".

PIR 1R60-75-148, "Response To CDR Action Item No. 16?".

PIR 1R54-BMS-1050, "Thermal Analysis Of PCB A1 Of The BMS Electronics".

PIR 1R60-75-153, "Micropump Priming".

PIR 1R60-75-157, "Test Of Expansion Bladder Material".

PIR 1R60-75-159, "Design Optimization Of BMS Septa".

PIR 1R54-1092, "Thermal Analysis Of BMS Assembly".

### Vendor Data

Phase Separator Motor data, ltr from IMC Magnetics Corp.

Flush Pump (serial No. 1063), Micropump test data sheets.

Urine Pump (serial No. 1062), Micropump test data sheets.

Pressure Sensor, operating and calibration data from Setra Systems, Inc.

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| | *CLASS. LTR. | OPERATION | PROGRAM | SEQUENCE NO. | REV. LTR. |
|---|---|---|---|---|---|
| PIR NO. | U | 1R60 | 75 | 208 | |

*USE "C" FOR CLASSIFIED AND "U" FOR UNCLASSIFIED

| FROM | TO |
|---|---|
| J. K. Mangialardi, Engineer - Environmental Engineering, Room #U-2437, VFSC X-5499 | G. L. Fogal, Bioengineering Programs Room #U-2437, VFSC Extension - 5636 |

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| 12-12-75 | | | |

SUBJECT

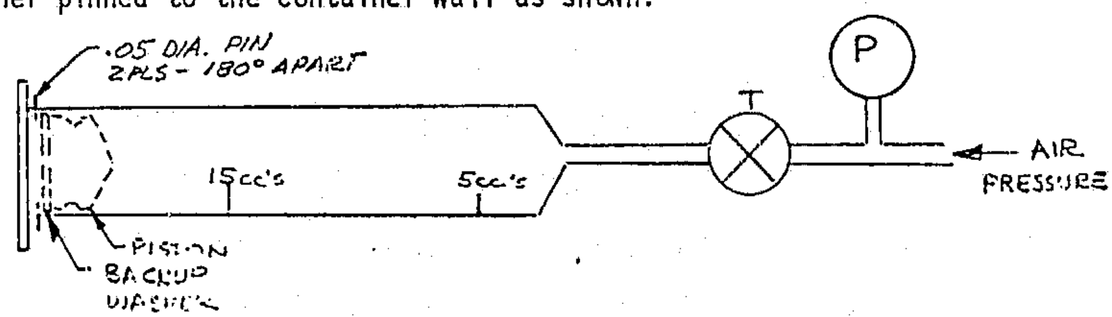
Preliminary Tests On Sample Container

INFORMATION REQUESTED/RELEASED

The following tests were performed on the sample containers using standard Becton Dickinson & Co. syringes modified as required:

1. Pressure Tests

These tests were made to determine the sample containers capability to withstand internal pressures with the rubber piston being held by a backup washer pinned to the container wall as shown:




Pressure was applied in increments of 5 psi. The corresponding change in diameter, if any, was checked at the 5 cc's and 15 cc's mark.

The results were:

| Pressure | Dia @ 15 cc's | Dia @ 5 cc's |
|---|---|---|
| 0 psig | .848 in | .842 in |
| 5 " | .848 " | .842 " |
| 10 " | .847 " | .840 " |
| 15 " | .847 " | .841 " |
| 20 " | .848 " | .842 " |

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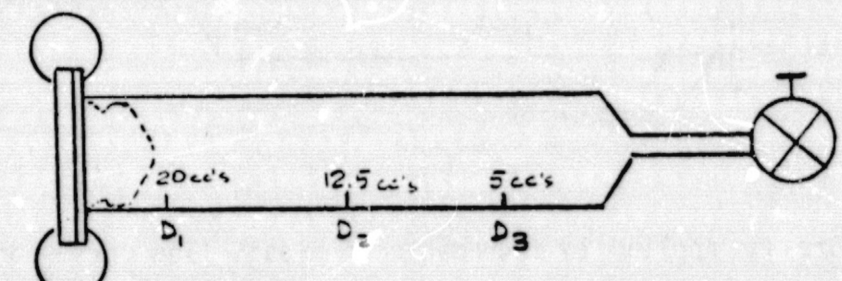
| Pressure | Dia @ 15 cc's | Dia @ 5 cc's |
|---|---|---|
| 25 psig | .850 in | .842 in |
| 30 " | .852 " | .842 " |
| 35 " | .852 " | .844 " |
| 40 " | .851 " | .843 " |
| 45 " | .851 " | .842 " |
| 50 " | .852 " | .844 " |

The test was stopped at this point as there was no need for further data. The diametrical expansion in the range of operation of the sample container is obviously insignificant.

2. Freezing Test Without Expansion Ring

These test were made to determine the sample container capability to withstand freezing after being totally filled and without an expansion ring. The sample container was filled with water after attaching a stop at the end of the container as shown and was placed in the freezer compartment of the lab refrigerator.




After several hours the container was removed and found to have increased in diameter as follows:

| | $D^1$ | $D^2$ | $D^3$ |
|---|---|---|---|
| Before Freezing | .853 in | .847 in | .842 in |
| After Freezing | .865 in | .850 in | .845 in |

The container was not significantly damaged although the surface was substantially crazed near the halfway legnth. Also the rubber piston had partially extruded between the clamped plate and the end tabs. This test was repeated with the same effect.

The same test was repeated using urine. The distortion appeared to be less significant:

| | $D^1$ | $D^2$ | $D^3$ |
|---|---|---|---|
| Before Freezing | .851 in | .847 in | .843 in |
| After Freezing | .857 in | .848 in | .843 in |

Extrusion of the rubber septum however was still significant.

3. Freezing Test With Expansion Ring

An expansion ring was made by inserting a 3/4" O.D. X 1/8" wall X 5/8" long latex rubber tube between the piston and the stop plate. The freezing test described in the previous section repeated with the following results:

| | $D^1$ | $D^2$ | $D^3$ |
|---|---|---|---|
| Before Freezing | .850 in | .847 in | .844 in |
| After Freezing | .855 in | .852 in | .852 in |

A second sample was also tested with the following results:

| | $D^1$ | $D^2$ | $D^3$ |
|---|---|---|---|
| Before Freezing | .850 in | .846 in | .842 in |
| After Freezing | .850 in | .851 in | .843 in |

In either case the piston moved back approximately 3/16 in. after the sample container was returned to ambient temperature.

There was no indication of damage or extrusion as experienced without the expansion ring. Water was used as fluid for the later two tests.

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| | | 1R60 | 75 | 143 | |

*USE "C" FOR CLASSIFIED AND "U" FOR UNCLASSIFIED

| FROM | TO |
|---|---|
| V. Long | G. Fogal |

| DATE SENT | DATE INFO. REQUIRED | PROJECT AND REQ. NO. | REFERENCE DIR. NO. |
|---|---|---|---|
| 6/10/75 | | | |

SUBJECT

FRONT PANEL SWITCHES FOR BMS

INFORMATION REQUESTED/RELEASED

The North American Rockwell document MF0004-002, Electrical Design Requirements for Electrical Equipment utilized on the Space Shuttle Vehicle, specifies that switches used shall be of environmentally or hermetically sealed type. Several switch types were considered.

Dialight manufactures attractive illuminated pushbutton switches of reportedly high reliability. However, none are environmentally sealed. They also manufacture some solid state contactless logic switches. These would suffice functionally for all of the front panel switches except the URINE COLLECT switch which must switch 28 volts DC. The solid state switches, however, do not contain qualifiable components, i.e., hermetically sealed transistors, LEDS, etc.

Microswitch offers some unilluminated push buttons which would be satisfactory and fit the space restraints of the present BMS electronics box. These push buttons are hermetically sealed type 703PB1. These don't appear, however, to offer a good panel seal.

Microswitch also offers an illuminated hermetically sealed push button. This switch, Series 2, is rather long and appears to be of questionable mechanical sturdiness. It might be possible to modify the switch slightly to reinforce it. The BMS enclosure, however, would have to be enlarged to get it to fit. In addition, panel seal would be a problem.

The Microswitch Toggle, TL Series, switch presently selected is environmentally sealed and has been used in a manned environment. In addition, it is much shorter than the Microswitch illuminated push buttons. The lamps chosen for indicators are manufactured by Control Switch, are sealed, and have a ruggedized filament with an average life of 60,000 hours.

A letter from J. Curtis, Man/System Branch, NASA - Marshall Space Flight Center indicates that the only notable place push buttons were used on Skylab was on the M131 experiment on the human vestibular function. The illuminated push buttons used were manufactured by Jayel Products Inc., Gardena, California. These are relatively small switches incorporating an hermetically sealed switch element and a sealed lamp assembly (not relampable, but replaceable as a unit). Functionally, they would meet all BMS electrical requirements, but would have to be modified to provide a panel seal. While the element is sealed, any liquid landing on the control panel could seep around the edges of the push button into the interior of the control box.

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A. Gorawitz
G. L. Fogal (3)
J. K. Mangialardi
R. W. Murray





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| ☐ 6 MOS. | ☐ 12 MOS. |
| ☐ MOS. | ☐ MOS. |

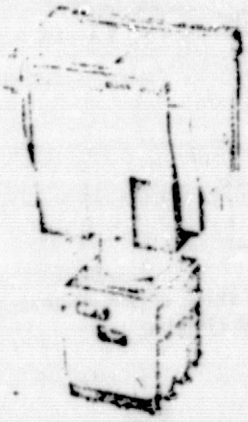
Based upon our investigation it is recommended that the TL Toggle Switch be used for this unit. It is a qualified device, meeting all electrical requirements and providing a panel seal.

The Jayel illuminated push button switch should be considered further for application to future units. If a panel seal can be effected, it would be entirely satisfactory.

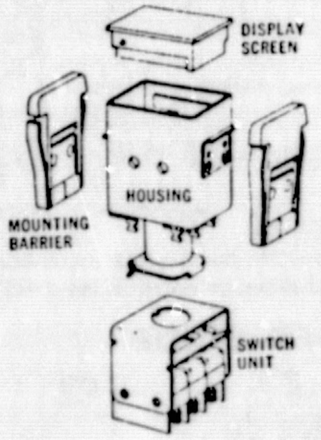
Solid state switches also have potential application. They are contactless and very reliable. More investigation is required, however, to determine if a qualifiable one may be obtained.

# SERIES 2 RECTANGULAR DISPLAY MODULAR LIGHTED



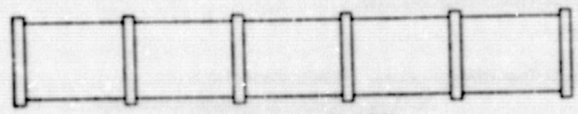


## Barrier Mount

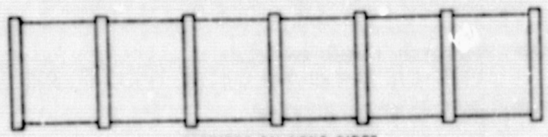



- MODULES ASSEMBLE EASILY, WITHOUT SPECIAL TOOLS
- UP TO FOUR-LAMP INDICATION
- THOUSANDS OF COLOR DISPLAY AND CIRCUIT CONTROL COMBINATIONS

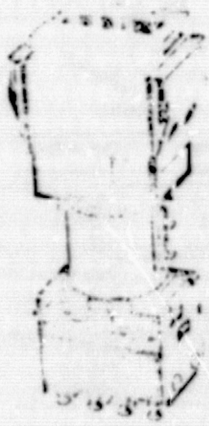
Barriers serve as mounting devices and separate the display screens to prevent accidental operation. The desired number of units are combined in a strip and snapped into the panel slot.



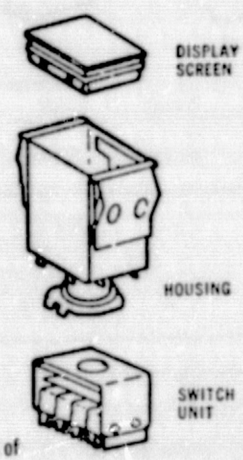
BARRIERS ON SHORT SIDES



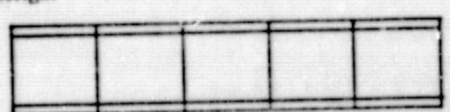
BARRIERS ON LONG SIDES



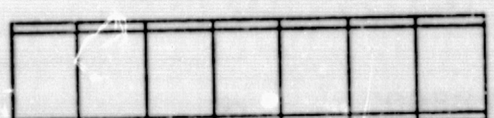
## Flange Mount*




Flange mounted units are supplied with the mounting devices ready-attached. They can be individually installed or replaced, and permit an overlay panel. Optional spacing barriers can be used to separate groupings.



FLANGES ON LONG SIDES



FLANGES ON SHORT SIDES

*Also refer to page A13 for details of MIL-S-22885 assembled devices.

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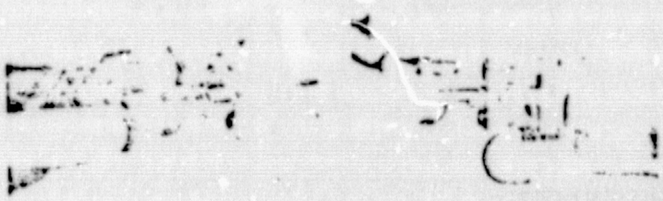
## FRONT OF PANEL RELAMPING



1. 2.

### TYPE 2C200 AND 2F200 HOUSINGS ARE RELAMPED WITHOUT TOOLS

Type 2C200 (operator-indicator) and 2F200 (indicator only) housings have a separate lampholder sector that can be removed to enable replacement of lamps or filters, without tools. The unit is keyed to maintain proper orientation.

1. Remove display screen/lampholder assembly.
2. Relamp and replace assembly.

LAMPS: T-1-3 4 flange base lamps are recommended.

1. 2

### USE LAMP TOOL WITH TYPE 2C AND 2F HOUSINGS

To easily remove and replace lamps or color filters from Type 2C (operator-indicator) or 2F (indicator only) housings, a Catalog Listing 15PA32 lamp tool is inserted into the socket until it bottoms against the lamp base flange. The glass bulb portion of the lamp is gripped, when installing.

1. Remove display screen.
2. Relamp with 15PA32 tool and replace screen.

LAMPS: T-1-3/4 grooved base lamps are recommended.

## SEALED PUSHBUTTON SWITCHES

### Type "700PB"

This type of pushbutton answers the need for maximum protection of contacts in applications where there are rapid changes in atmospheric and environmental conditions. "HM" basic switches (described on page 10) are used in the pushbutton assembly to achieve savings in size and weight without sacrificing precision performance. The over-center snap actuator mechanism provides a definite feel of switching action and prevent tease actuation. Operation is momentary; switches are operated when the button is pushed and released when the pressure is removed from the button.

**Military Specifications:** ("HM" basic switches)
MIL-E-5272 (Explosion-proof)
MIL-S-8805 (Corrosion-resistance)

**Seal Definition:** Hermetic (basic switches)
(Enclosure Design Symbol per MIL-S-8805)

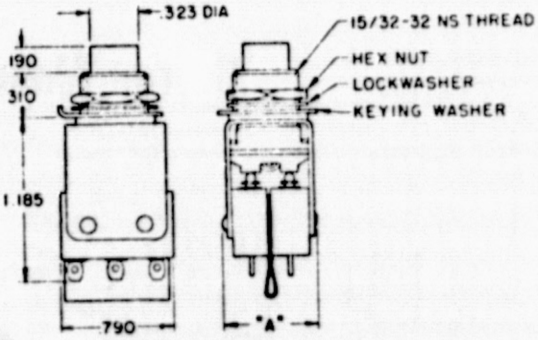
**Temperature Range:** −67°F to +158°F

**Circuitry:** Two Single-Pole Double-Throw Circuits
Three Single-Pole Double-Throw Circuits
Four Single-Pole Double-Throw Circuits

**Electrical Rating:** 3 amps. ind., 5 amps. res., 28 vdc and 115 vac 400 cps.

**Operating Force:** 2-Pole—30 oz. approx.
3-Pole—35 oz. approx.
4-Pole—40 oz. approx.

**Dimensions**




**Button Options**
The concave buttons are available in three colors: black, red and green as noted in the ORDER GUIDE.

## ORDER GUIDE


702PB


703PB


704PB

| Circuitry | Weight | Dimension "A" | Button Color | Order This Listing |
|---|---|---|---|---|
| Two-Pole | 0.8 oz. | .656 max. | Black<br>Red<br>Green | 702PB1<br>702PB2<br>702PB3 |
| Three-Pole | 1.1 oz. | .906 max. | Black<br>Red<br>Green | 703PB1<br>703PB2<br>703PB3 |
| Four-Pole | 1.3 oz. | 1.183 max. | Black<br>Red<br>Green | 704PB1<br>704PB2<br>704PB3 |

### Type "2PB900"


2PB901-T2

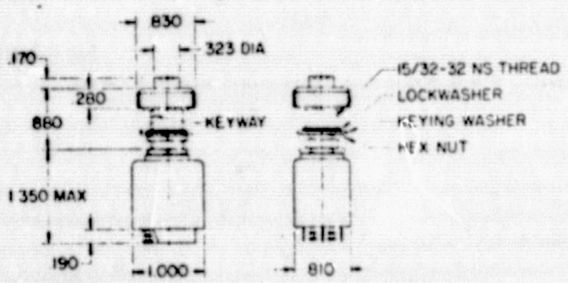
"2PB900" momentary-action (push-on release-off) pushbutton switches are recommended for applications that require a compact weather-proof manual switch. Concave black plastic buttons and an overcenter snap mechanism provide a good operating feel and prevent teased operation.

**Seal Definition:** Panel, bushing, plunger and terminal seals enable this switch to meet the submergence requirements of MIL-STD-108D (up to 10 psi water pressure for one hour). The panel, bushing and plunger seals are contained in the chrome finish knurled facenut. The two single-pole double-throw basic switches are potted into the brass enclosure to seal them from back of panel contaminants.

**Temperature Range:** −65°F to +158°F.

**Circuitry:** Two single-pole double-throw circuits

**Dimensions**




**Electrical Rating:**

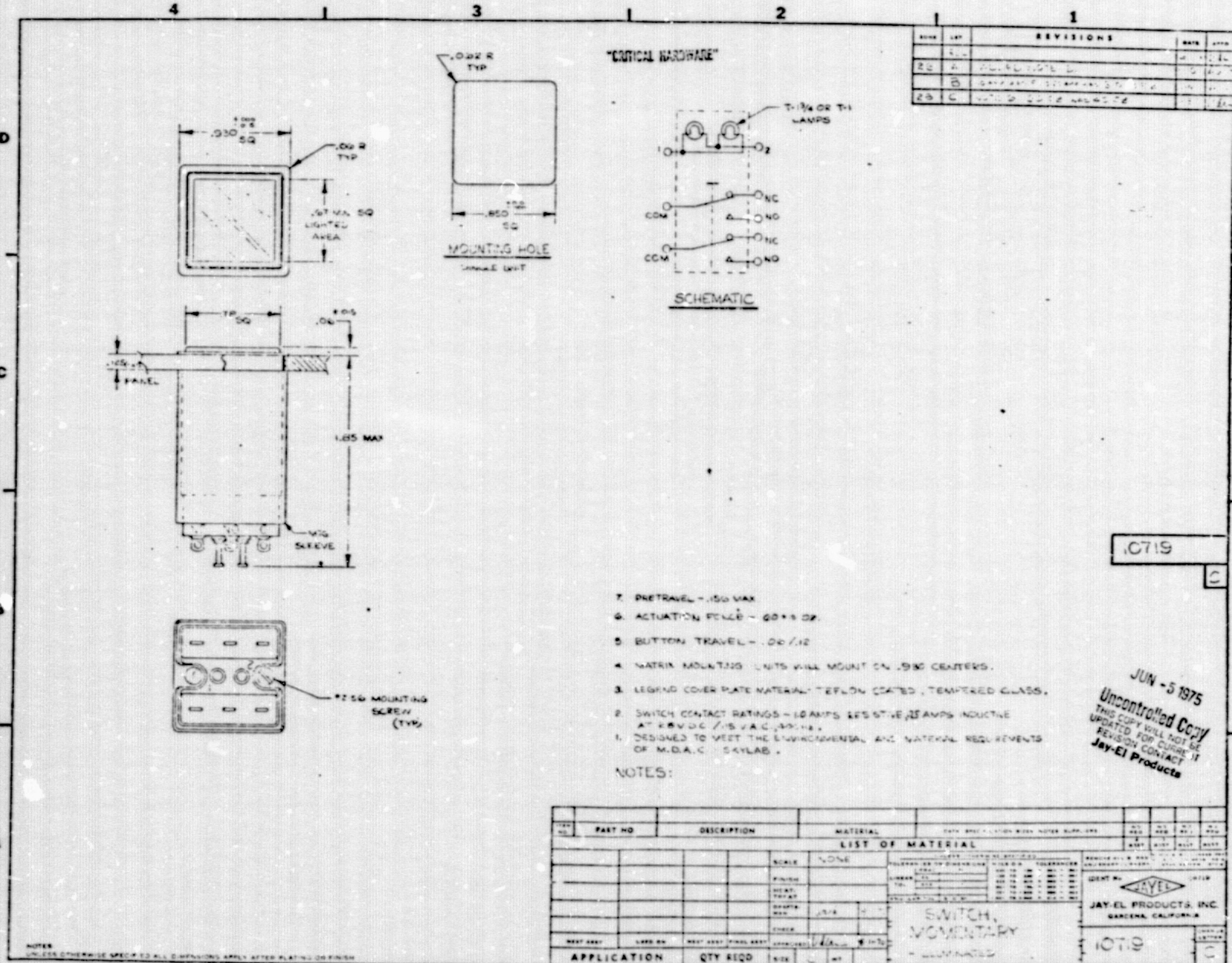
| VOLTAGE | AMPERAGE Sea Level Ind. | Sea Level Res. | 50,000 ft. Ind. | 50,000 ft. Res. | Maximum Inrush |
|---|---|---|---|---|---|
| 30 DC | 3 | 5 | 2.5 | 5 | 24 |
| 250 AC | — | 5 | — | — | — |

**Operating Force:** 35 oz. (approx.)

**Weight:** 2.5 oz. max.

**Order This Listing:** 2PB901-T2

**Note:** For variations of this listing contact a MICRO SWITCH Branch Office.

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FROM J. K. Mangialardi, Engineer-Environmental Engineering, Room #U-1243, VFSC X-5499

TO G. L. Fogal, Bioengineering Program Manager Room #U-1240, VFSC

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| 6-9-75 | | | |

SUBJECT

Response To C.D.R. Action Item #2

INFORMATION REQUESTED/RELEASED

The following action item was generated during the BMS Critical Design Review held on May 5 and 6, 1975:

"Check on capability of filled portable tank to withstand internal fluid pressure resulting from thermal expansion."

The maximum ambient temperature specified for the BMS is 100°F.
The maximum structural and storage temperatures are 120°F and 150°F, respectively.

Although the water tank will normally be filled and used only at ambient temperatures, the following analysis is based on the assumption that the water tank is filled to maximum capacity at maximum filling pressure (= 17 psi) and exposed to 150°F for several hours.

The increase in water volume due to temperature change from 70°F to 150°F is 2.8896 $in^3$.

The increase in volume for the aluminum tank for the same $\Delta t$ = 1.2741 $in^3$.

The net volume of water that must be accommodated to prevent overpressure in the tank is

$$2.889\ in^3 - 1.274\ in^3 = 1.655\ in^3 = 27.13\ cc's$$

cc: T. J. Greiner
J. K. Mangialardi
R. W. Murray

PAGE NO. 1 of 2

RETENTION REQUIREMENTS

| COPIES FOR | MASTERS FOR |
|---|---|
| 1 MO. | 3 MOS |
| 3 MOS | 6 MOS |
| 6 MOS | 12 MOS |
| MOS | MOS |
| | DO NOT DESTROY |

The pressure capability of the aluminum tank is 95 psi. This capability is significantly reduced by the observation port which is made from a Lexan disk .125 thick with a maximum calculated pressure rating of 58 psi.

The pressure calculations are based on a safety factor four times the operating pressures and meet the requirements of the ASME Pressure Vessel Code Section VIII.

The restrained expansion of approximately 27 cc's of water, even though somewhat lessened by water compressibility, rubber tank bladder compression, and initial elastic expansion of the aluminum tank would cause internal pressures far in excess of the permissible 58 psi unless relieved by some internal device which will absorb the 27 cc's of water volume increase.

This device will be a 200 cc volume closed pores foam rubber sleeve (or equivalent) added along the tank stem pipe.

The usable volume of the tank without the additional sleeve is a nominal 5,125 cc's.

The volume of the sleeve is reduced to 129.5 cc's @ 8 psi which is the minimum filling water pressure and 92.7 cc's at 17 psi which is the maximum filling pressure.

The usable volume of water with the additional sleeve will then vary from a minimum of 4,995 to a maximum of 5,032 cc's approximately.

The foam sleeve will further compress to accommodate the 27.13 cc's due to net water expansion at 150°F. The pressure required is approximately 30 psi which is well below the 58 psi allowable due to the Lexan window.

**GENERAL ELECTRIC**
SPACE DIVISION
PHILADELPHIA

# PROGRAM INFORMATION REQUEST / RELEASE

| PIR NO. | *CLASS. LTR. | OPERATION | PROGRAM | SEQUENCE NO. | REV. LTR. |
|---|---|---|---|---|---|
| | U | 1R60 | 75 | 148 | |

*USE "C" FOR CLASSIFIED AND "U" FOR UNCLASSIFIED

FROM J. K. Mangialardi, Engineer-Environmental Engineering, Room #U-1243, VFSC X-5499

TO G. L. Fogal, Bioengineering Program Manager Room #U-1240, VFSC

| DATE SENT | DATE INFO. REQUIRED | PROJECT AND REQ. NO. | REFERENCE DIR. NO. |
|---|---|---|---|
| 6-10-75 | | | |

SUBJECT

Response to C.D.R. Action Item #16

INFORMATION REQUESTED/RELEASED

The following action item was generated during the BMS Critical Design Review held on May 5 and 6, 1975:

"Confirm that liquid retention on outer phase separator screen is not significant for BMS application"

The response to this action item was obtained by actual test using a screen of the same wire diameter and mesh size as specified on Drawing ER47B231805.

The size of the test screen was 2.25 I.D. x 1.75 high with an area of 17.8 in$^2$ which is approximately 5% larger than the designed part.

The screen was slip fitted over an existing adapter plate attached to a motor set to rotate at 375 rpm.

The motor speed was checked with a strobotac (General Radio Company, Type 1531-A).

The test was performed in the following steps:

1. Measure weight of screen = 18 grams
2. Measure weight of water retained by screen under static conditions = 3 to 4 grams. (Note: This is a difficult measurement due to the effect of gravity. The results are approximate and are intented to give only an indication of the effectiveness of the dynamic action of the phase separator).

Distribution

J. K. Mangialardi
R. W. Murray

PAGE NO 1 of 2

RETENTION REQUIREMENTS

| COPIES FOR | MASTERS FOR |
|---|---|
| 1 MOS. | 3 MOS. |
| 3 MOS. | 6 MOS. |
| 6 MOS. | 12 MOS. |
| MOS. | MOS. |
| | DO NOT DESTROY |

FORM 1020 (REV. 1-70)

3. Measure weight of water retained by screen after placing same on the adapter plate and rotating it at 375 rpm for 30 seconds. The water retained was between 0.1 to 0.2 grams.

This test confirms that liquid retention on the phase separator screen is not significant.

h

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SPACE DIVISION
PHILADELPHIA

# PROGRAM INFORMATION REQUEST / RELEASE

| PIR NO. | *CLASS. LTR. | OPERATION | PROGRAM | SEQUENCE NO. | REV. LTR. |
|---|---|---|---|---|---|
| | U | 1R54 | BMS | 1050 | |

*USE "C" FOR CLASSIFIED AND "U" FOR UNCLASSIFIED

| FROM | TO |
|---|---|
| F. Drummond | J. Billings |

| DATE SENT | DATE INFO. REQUIRED | PROJECT AND REQ. NO. | REFERENCE DIR. NO. |
|---|---|---|---|
| 6/18/75 | | | 1R54-998 |

SUBJECT

THERMAL ANALYSIS OF PCB A1 OF THE BMS ELECTRONICS

INFORMATION REQUESTED/RELEASED


## Summary

The temperature rises of the piece parts of the subject PCB have been calculated. These temperature rises must be added to the BMS assembly temperature in order to obtain maximum part temperatures. The assembly temperature is not known at this time since the pump and phase separator motor heat dissipations are not defined.


## Requirements

The critical parts of the PWB A1 in the BMS electronics are listed on Table 1 along with their heat dissipation and duty cycle.

## Analysis - Math Model

The PWB A1, shown in Figure 1 has been modeled mathimatically in a 277 mode model. The substrate is an .062" thick laminated fiberglas covered with an 0.003" thick film of copper. The effective conductivity of the card is 1.088 BTU Hr. in °F. This card is supported on the two long sides (4.5") by "Bircher" clips. An effective contact conductance of 0.236 BTU per inch of length, per °F was used to couple the board to the clip. The clip is riveted at each end to the box, giving an effective conductance of 0.666 BTU/hr °F. Approximately 50 wires (25 - 24 gage and 25 - 26 gage) connect to the bottom of the PWB. An average length of 5" was assumed for these wires to the box-mounted connector.

All the input data to the math model is given in the appendix, including the predicted PWB temperatures (Table A). A reference or sink temperature of 100°F was assumed.

## Results

The significant temperatures of the PCB from Table A have been extracted and are shown on Table 2. These temperatures are listed under $\Delta t1$. Since the reference temperature was 100°F, the 100 was subtracted so that the

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J. Billings, U2446
L. Blomstrom, U2439
J. Mangialardi, U1243
V. Young, U2446

PAGE NO. ___ OF ___

RETENTION REQUIREMENTS

| COPIES FOR | MASTERS FOR |
|---|---|
| 1 MOS. | 3 MOS. |
| 3 MOS. | 6 MOS. |
| 6 MOS. | 12 MOS. |
| MOS. | MOS. |
| | DONT DESTROY |



FORM 1020 B REV. (9-70)

result is a temperature rise above the environment. The values shown under $\Delta t2$ are the temperature difference required to transfer the heat from the part to the board. Under $\Delta t3$ are the temperature differences within the piece part to transfer the heat to the case. The last column gives the maximum temperature of the piece parts. It will be seen that this column is blank as is the column marked Tsink. The sink (or box) temperature is not yet known since the assembly has not been analyzed in adequate detail. This analysis must await the determination of the final heat dissipations of the pump and separator motors.

However, it should be noted that the required sink temperature must equal or exceed 65°C (149°F) in order for the critical temperature of any part to be attained or exceeded. There is a low probability that the temperature of the assembly will reach 65°C. A preliminary analysis (ref. 1) indicated that, with no heat loss, the average temperature at the end of one hour of continuous operation will be 140°F (60°C).

## Table 1

## CRITICAL PARTS REQUIREMENTS

| Piece Part | Limit Temperature °C | Heat Dissipation mW | Duty Cycle % |
|---|---|---|---|
| Urine Pump Relay Driver - A49 | 125 | 80 | 39 |
| Flush Pump Relay Driver - A50 | | 80 | 10 |
| Sample Lamp Driver - A29 | | 60 | 17 |
| Dump Switch Lamp Driver - A30 | | 60 | 35 |
| Flush Lamp Driver - A31 | | 60 | 10 |
| Sample Collect Lamp Driver - A32 | | 60 | 40 |
| Sample Container Lamp Driver - A51 | | 120 | 70 |
| Power/Phase Separator Relay Driver - A33 | | 80 | 100 |
| S.C. ID. Sensor Bias Driver - A35 | 125 | 30 | 13 |
| Reistor, Carbon - R1 | 100 | 123 | 100 |
| Reistor, WireWound - R27 | 125 | 420 | 17 |
| Integrated Circuit Logic - Var. | 125 | 0.6 @ (25 total) | 100 |

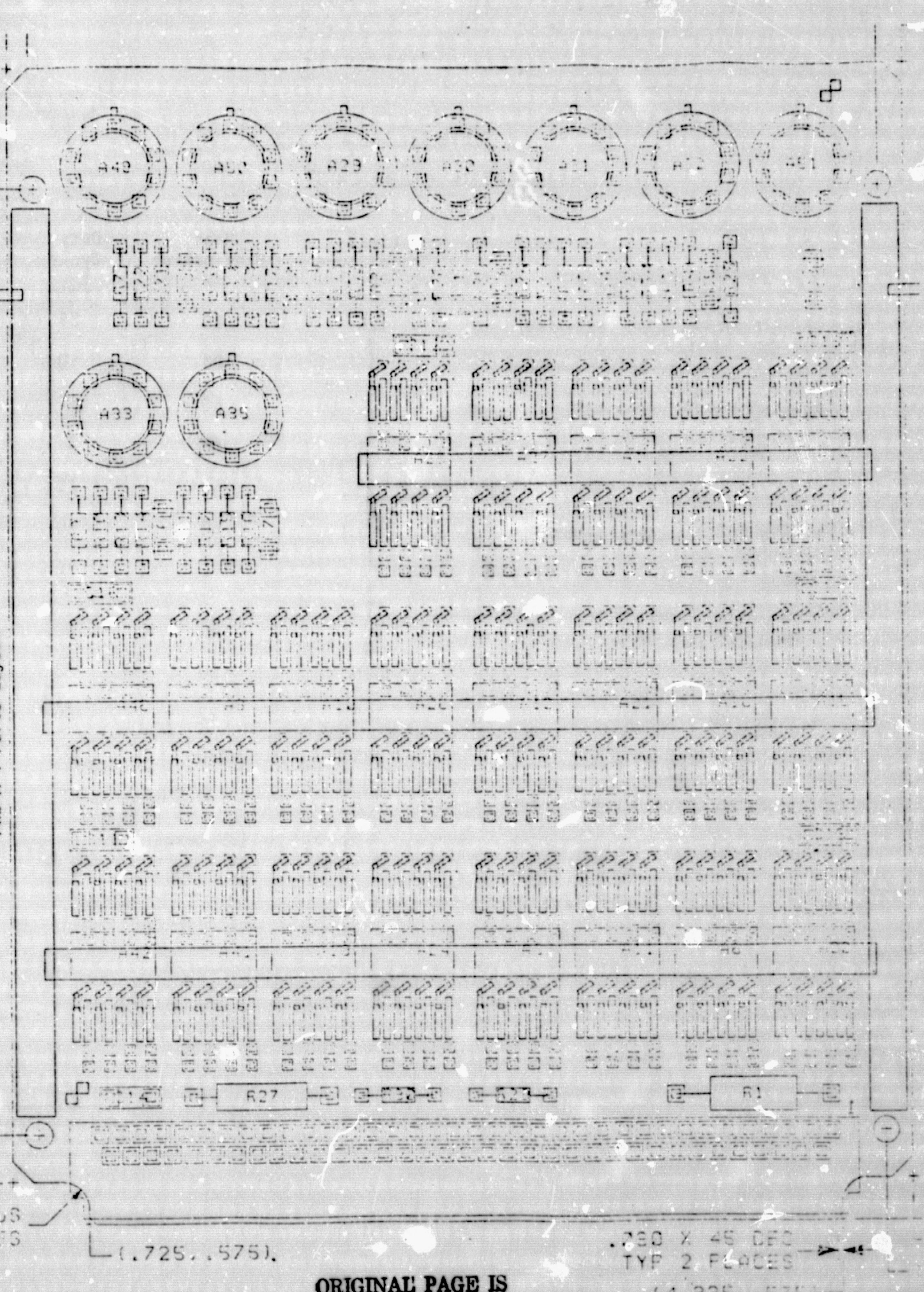


Figure 1
PWB A-1 Parts Layout

Table 2

PREDICTED PERFORMANCE OF SIGNIFICANT PARTS

| Piece Part | Tsink °F/°C | Δt1 °F/°C | Δt2 °C | Δt3 °C | Tmore °F/°C |
|---|---|---|---|---|---|
| A49 - Urine Pump Relay Driver | | 9.8/5.4 | .13 | 4.68 | |
| A50 - Flush Pump Relay Driver | | 11.05/6.14 | .03 | 1.2 | |
| A29 - Sample Lamp, Driver | | 11.96/6.64 | .04 | 1.5 | |
| A30 - Dump Switch Lamp Driver | | 11.96/6.64 | .08 | 3.0 | |
| A31 - Flush "On" Lamp Driver | | 11.2/6.2 | .025 | 0.9 | |
| A32 - Sample Collect Lamp Driver | | 9.9/5.5 | 0.1 | 3.6 | |
| A51 - Sample Container Lamp Driver | | 8.0/4.4 | .04 | 1.5 | |
| A33 - Power/Phase Separator Relay Drive | | 8.45/4.7 | .34 | 12.0 | |
| A35 - S.C. ID. Sensor Bias Relay | | 9.36/5.2 | .017 | .6 | |
| R1 - Resistor | | 7.42/4.0 | .01 | - | |
| Integrated Circuit Logic | | 9.0/5.0 (maximum) | <.01 | ~.1 | |

(1) $T_{max} = T_{sink} + \Delta t1 + \Delta t2 + \Delta t3$

$\Delta t1$ - temperature rise of piece part above case.

$\Delta t2$ - tempeature difference, PCB to piece part case.

$\Delta t3$ - temperature rise of PCB under piece part above sink.

C.2

APPENDIX

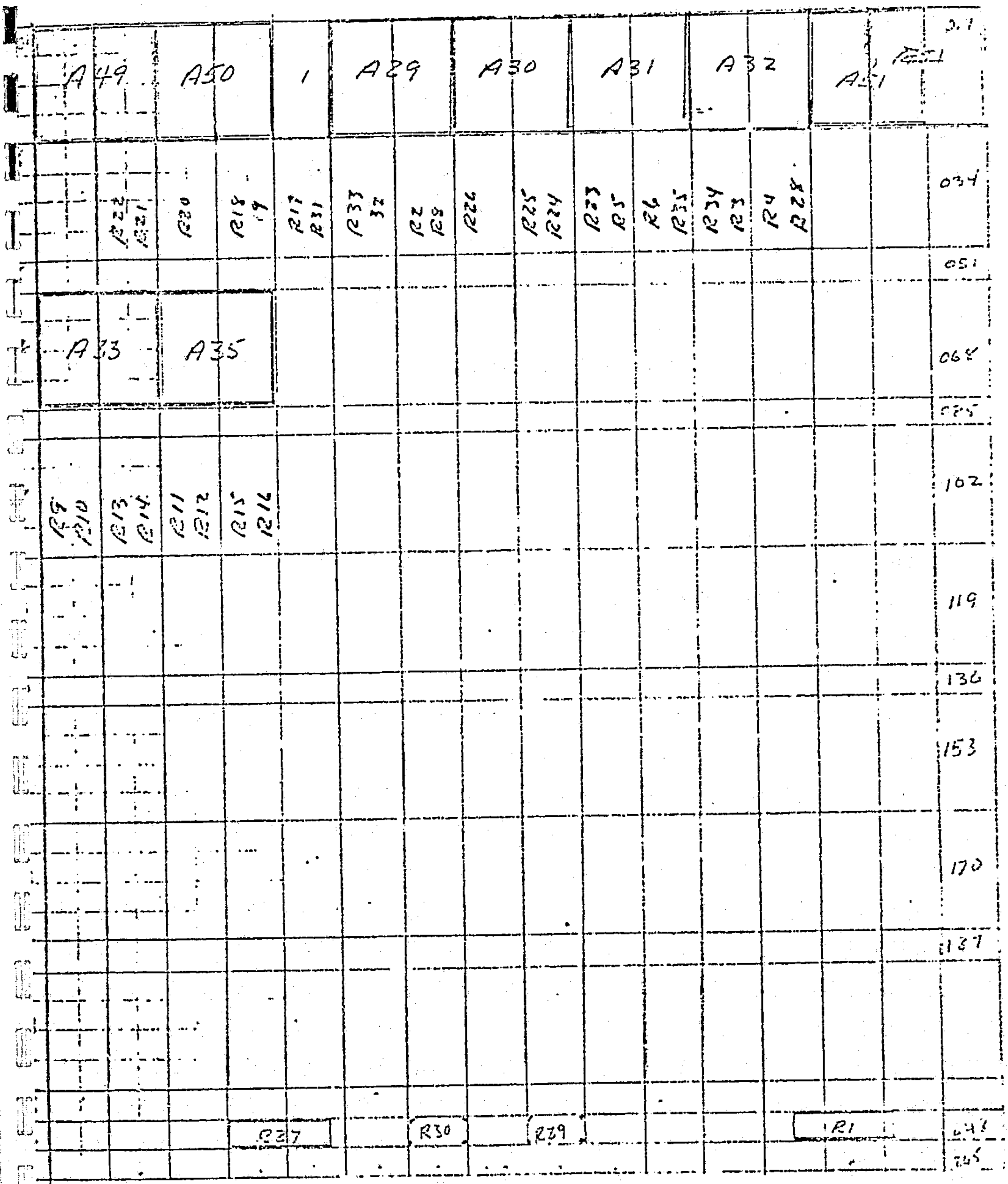


Figure A1
Nodal Matrix

TABLE A1

BHS

CONDUCTION CONNECTIONS BTU/HR-F

| I | J | C(I,J) | I | J | C(I,J) | I | J | C(I,J) |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 0.13494000 | 2 | 3 | 0.13494000 | 3 | 4 | 0.13494000 |
| 4 | 5 | 0.13494000 | 5 | 6 | 0.13494000 | 6 | 7 | 0.13494000 |
| 7 | 8 | 0.13494000 | 8 | 9 | 0.13494000 | 9 | 10 | 0.13494000 |
| 10 | 11 | 0.13494000 | 11 | 12 | 0.13494000 | 12 | 13 | 0.13494000 |
| 13 | 14 | 0.13494000 | 14 | 15 | 0.13494000 | 15 | 16 | 0.13494000 |
| 16 | 17 | 0.13494000 | 18 | 19 | 0.13494000 | 19 | 20 | 0.13494000 |
| 20 | 21 | 0.13494000 | 21 | 22 | 0.13494000 | 22 | 23 | 0.13494000 |
| 23 | 24 | 0.13494000 | 24 | 25 | 0.13494000 | 25 | 26 | 0.13494000 |
| 26 | 27 | 0.13494000 | 27 | 28 | 0.13494000 | 28 | 29 | 0.13494000 |
| 29 | 30 | 0.13494000 | 30 | 31 | 0.13494000 | 31 | 32 | 0.13494000 |
| 32 | 33 | 0.13494000 | 33 | 34 | 0.13494000 | 1 | 18 | 0.03373000 |
| 2 | 19 | 0.03373000 | 3 | 20 | 0.03373000 | 4 | 21 | 0.03373000 |
| 5 | 22 | 0.03373000 | 6 | 23 | 0.03373000 | 7 | 24 | 0.03373000 |
| 8 | 25 | 0.03373000 | 9 | 26 | 0.03373000 | 10 | 27 | 0.03373000 |
| 11 | 28 | 0.03373000 | 12 | 29 | 0.03373000 | 13 | 30 | 0.03373000 |
| 14 | 31 | 0.03373000 | 15 | 32 | 0.03373000 | 16 | 33 | 0.03373000 |
| 19 | 36 | 0.05397000 | 20 | 37 | 0.05397000 | 21 | 38 | 0.05397000 |
| 22 | 39 | 0.05397000 | 23 | 40 | 0.05397000 | 24 | 41 | 0.05397000 |
| 25 | 42 | 0.05397000 | 26 | 43 | 0.05397000 | 27 | 44 | 0.05397000 |
| 28 | 45 | 0.05397000 | 29 | 46 | 0.05397000 | 30 | 47 | 0.05397000 |
| 31 | 48 | 0.05397000 | 32 | 49 | 0.05397000 | 33 | 50 | 0.05397000 |
| 35 | 36 | 0.03373000 | 36 | 37 | 0.03373000 | 37 | 38 | 0.03373000 |
| 38 | 39 | 0.03373000 | 39 | 40 | 0.03373000 | 40 | 41 | 0.03373000 |
| 41 | 42 | 0.03373000 | 42 | 43 | 0.03373000 | 43 | 44 | 0.03373000 |

TABLE A1 (continued)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 39 | 56 | 0,05397000 | 40 | 57 | 0,05397000 | 41 | 58 | 0,05397000 |
| 42 | 59 | 0,05397000 | 43 | 60 | 0,05397000 | 44 | 61 | 0,05397000 |
| 45 | 62 | 0,05397000 | 46 | 63 | 0,05397000 | 47 | 64 | 0,05397000 |
| 48 | 65 | 0,05397000 | 49 | 66 | 0,05397000 | 50 | 67 | 0,05397000 |
| 52 | 53 | 0,13494000 | 53 | 54 | 0,13494000 | 54 | 55 | 0,13494000 |
| 55 | 56 | 0,13494000 | 56 | 57 | 0,13494000 | 57 | 58 | 0,13494000 |
| 58 | 59 | 0,13494000 | 59 | 60 | 0,13494000 | 60 | 61 | 0,13494000 |
| 61 | 62 | 0,13494000 | 62 | 63 | 0,13494000 | 63 | 64 | 0,13494000 |
| 64 | 65 | 0,13494000 | 65 | 66 | 0,13494000 | 66 | 67 | 0,13494000 |
| 53 | 70 | 0,05397000 | 54 | 71 | 0,05397000 | 55 | 72 | 0,05397000 |
| 56 | 73 | 0,05397000 | 57 | 74 | 0,05397000 | 58 | 75 | 0,05397000 |
| 59 | 76 | 0,05397000 | 60 | 77 | 0,05397000 | 61 | 78 | 0,05397000 |
| 62 | 79 | 0,05397000 | 63 | 80 | 0,05397000 | 64 | 81 | 0,05397000 |
| 65 | 82 | 0,05397000 | 66 | 83 | 0,05397000 | 67 | 84 | 0,05397000 |
| 69 | 70 | 0,03373000 | 70 | 71 | 0,03373000 | 71 | 72 | 0,03373000 |
| 72 | 73 | 0,03373000 | 73 | 74 | 0,03373000 | 74 | 75 | 0,03373000 |
| 75 | 76 | 0,03373000 | 76 | 77 | 0,03373000 | 77 | 78 | 0,03373000 |
| 78 | 79 | 0,03373000 | 79 | 80 | 0,03373000 | 80 | 81 | 0,03373000 |
| 81 | 82 | 0,03373000 | 82 | 83 | 0,03373000 | 83 | 84 | 0,03373000 |
| 70 | 87 | 0,05397000 | 71 | 88 | 0,05397000 | 72 | 89 | 0,05397000 |
| 73 | 90 | 0,05397000 | 74 | 91 | 0,05397000 | 75 | 92 | 0,05397000 |
| 76 | 93 | 0,05397000 | 77 | 94 | 0,05397000 | 78 | 95 | 0,05397000 |
| 79 | 96 | 0,05397000 | 80 | 97 | 0,05397000 | 81 | 98 | 0,05397000 |
| 82 | 99 | 0,05397000 | 83 | 100 | 0,05397000 | 84 | 101 | 0,05397000 |
| 86 | 87 | 0,13494000 | 87 | 88 | 0,13494000 | 88 | 89 | 0,13494000 |
| 89 | 90 | 0,13494000 | 90 | 91 | 0,13494000 | 91 | 92 | 0,13494000 |
| 92 | 93 | 0,13494000 | 93 | 94 | 0,13494000 | 94 | 95 | 0,13494000 |
| 95 | 96 | 0,13494000 | 96 | 97 | [illegible] | 97 | 98 | [illegible] |

TABLE A1 (continued)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 105 | 106 | 0,13494000 | 106 | 107 | 0,13494000 | 107 | 108 | 0,13494000 |
| 108 | 109 | 0,13494000 | 109 | 110 | 0,13494000 | 110 | 111 | 0,13494000 |
| 111 | 112 | 0,13494000 | 112 | 113 | 0,13494000 | 113 | 114 | 0,13494000 |
| 114 | 115 | 0,13494000 | 115 | 116 | 0,13494000 | 116 | 117 | 0,13494000 |
| 117 | 118 | 0,13494000 | 118 | 119 | 0,13494000 | 86 | 103 | 0,03373000 |
| 87 | 104 | 0,03373000 | 88 | 105 | 0,03373000 | 89 | 106 | 0,03373000 |
| 90 | 107 | 0,03373000 | 91 | 108 | 0,03373000 | 92 | 109 | 0,03373000 |
| 93 | 110 | 0,03373000 | 94 | 111 | 0,03373000 | 95 | 112 | 0,03373000 |
| 96 | 113 | 0,03373000 | 97 | 114 | 0,03373000 | 98 | 115 | 0,03373000 |
| 99 | 116 | 0,03373000 | 100 | 117 | 0,03373000 | 101 | 118 | 0,03373000 |
| 104 | 121 | 0,05397000 | 105 | 122 | 0,05397000 | 106 | 123 | 0,05397000 |
| 107 | 124 | 0,05397000 | 108 | 125 | 0,05397000 | 109 | 126 | 0,05397000 |
| 110 | 127 | 0,05397000 | 111 | 128 | 0,05397000 | 112 | 129 | 0,05397000 |
| 113 | 130 | 0,05397000 | 114 | 131 | 0,05397000 | 115 | 132 | 0,05397000 |
| 116 | 133 | 0,05397000 | 117 | 134 | 0,05397000 | 118 | 135 | 0,05397000 |
| 120 | 121 | 0,03373000 | 121 | 122 | 0,03373000 | 122 | 123 | 0,03373000 |
| 123 | 124 | 0,03373000 | 124 | 125 | 0,03373000 | 125 | 126 | 0,03373000 |
| 126 | 127 | 0,03373000 | 127 | 128 | 0,03373000 | 128 | 129 | 0,03373000 |
| 129 | 130 | 0,03373000 | 130 | 131 | 0,03373000 | 131 | 132 | 0,03373000 |
| 132 | 133 | 0,03373000 | 133 | 134 | 0,03373000 | 134 | 135 | 0,03373000 |
| 121 | 138 | 0,05397000 | 122 | 139 | 0,05397000 | 123 | 140 | 0,05397000 |
| 124 | 141 | 0,05397000 | 125 | 142 | 0,05397000 | 126 | 143 | 0,05397000 |
| 127 | 144 | 0,05397000 | 128 | 145 | 0,05397000 | 129 | 146 | 0,05397000 |
| 130 | 147 | 0,05397000 | 131 | 148 | 0,05397000 | 132 | 149 | 0,05397000 |
| 133 | 150 | 0,05397000 | 134 | 151 | 0,05397000 | 135 | 152 | 0,05397000 |
| 137 | 138 | 0,13494000 | 138 | 139 | 0,13494000 | 139 | 140 | 0,13494000 |
| 140 | 141 | 0,13494000 | 141 | 142 | 0,13494000 | 142 | 143 | 0,13494000 |
| 143 | 144 | 0,13494000 | 144 | 145 | 0,13494000 | 145 | 146 | 0,13494000 |

TABLE A1 (continued)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 156 | 157 | 0,13494000 | 157 | 158 | 0,13494000 | 158 | 159 | 0,13494000 |
| 159 | 160 | 0,13494000 | 160 | 161 | 0,13494000 | 161 | 162 | 0,13494000 |
| 162 | 163 | 0,13494000 | 163 | 164 | 0,13494000 | 164 | 165 | 0,13494000 |
| 165 | 166 | 0,13494000 | 166 | 167 | 0,13494000 | 167 | 168 | 0,13494000 |
| 168 | 169 | 0,13494000 | 169 | 170 | 0,13494000 | 137 | 154 | 0,03373000 |
| 138 | 155 | 0,03373000 | 139 | 156 | 0,03373000 | 140 | 157 | 0,03373000 |
| 141 | 158 | 0,03373000 | 142 | 159 | 0,03373000 | 143 | 160 | 0,03373000 |
| 144 | 161 | 0,03373000 | 145 | 162 | 0,03373000 | 146 | 163 | 0,03373000 |
| 147 | 164 | 0,03373000 | 148 | 165 | 0,03373000 | 149 | 166 | 0,03373000 |
| 150 | 167 | 0,03373000 | 151 | 168 | 0,03373000 | 152 | 169 | 0,03373000 |
| 155 | 172 | 0,05397000 | 156 | 173 | 0,05397000 | 157 | 174 | 0,05397000 |
| 158 | 175 | 0,05397000 | 159 | 176 | 0,05397000 | 160 | 177 | 0,05397000 |
| 161 | 178 | 0,05397000 | 162 | 179 | 0,05397000 | 163 | 180 | 0,05397000 |
| 164 | 181 | 0,05397000 | 165 | 182 | 0,05397000 | 166 | 183 | 0,05397000 |
| 167 | 184 | 0,05397000 | 168 | 185 | 0,05397000 | 169 | 186 | 0,05397000 |
| 171 | 172 | 0,03373000 | 172 | 173 | 0,03373000 | 173 | 174 | 0,03373000 |
| 174 | 175 | 0,03373000 | 175 | 176 | 0,03373000 | 176 | 177 | 0,03373000 |
| 177 | 178 | 0.03373000 | 178 | 179 | 0,03373000 | 179 | 180 | 0,03373000 |
| 180 | 181 | 0,03373000 | 181 | 182 | 0,03373000 | 182 | 183 | 0,03373000 |
| 183 | 184 | 0,03373000 | 184 | 185 | 0,03373000 | 185 | 186 | 0,03373000 |
| 172 | 199 | 0,05397000 | 173 | 200 | 0,05397000 | 174 | 201 | 0,05397000 |
| 175 | 202 | 0,05397000 | 176 | 203 | 0,05397000 | 177 | 204 | 0,05397000 |
| 178 | 205 | 0,05397000 | 179 | 206 | 0,05397000 | 180 | 207 | 0,05397000 |
| 181 | 208 | 0,05397000 | 182 | 209 | 0,05397000 | 183 | 210 | 0,05397000 |
| 184 | 211 | 0,05397000 | 185 | 212 | 0,05397000 | 186 | 213 | 0,05397000 |
| 198 | 199 | 0.13490000 | 199 | 200 | 0.13490000 | 200 | 201 | 0.13490000 |
| 201 | 202 | 0.13490000 | 202 | 203 | 0.13490000 | 203 | 204 | 0.13490000 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

TABLE A1 (continued)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 199 | 216 | 0.05397000 | 200 | 217 | 0.05397000 | 201 | 218 | 0.05397000 |
| 202 | 219 | 0.05397000 | 203 | 220 | 0.05397000 | 204 | 221 | 0.05397000 |
| 205 | 222 | 0.05397000 | 206 | 223 | 0.05397000 | 207 | 224 | 0.05397000 |
| 208 | 225 | 0.05397000 | 209 | 226 | 0.05397000 | 210 | 227 | 0.05397000 |
| 211 | 228 | 0.05397000 | 212 | 229 | 0.05397000 | 213 | 230 | 0.05397000 |
| 215 | 216 | 0.03373000 | 216 | 217 | 0.03373000 | 217 | 218 | 0.03373000 |
| 218 | 219 | 0.03373000 | 219 | 220 | 0.03373000 | 220 | 221 | 0.03373000 |
| 221 | 222 | 0.03373000 | 222 | 223 | 0.03373000 | 223 | 224 | 0.03373000 |
| 224 | 225 | 0.03373000 | 225 | 226 | 0.03373000 | 226 | 227 | 0.03373000 |
| 227 | 228 | 0.03373000 | 228 | 229 | 0.03373000 | 229 | 230 | 0.03373000 |
| 230 | 231 | 0.03373000 | 232 | 233 | 0.03373000 | 233 | 234 | 0.03373000 |
| 234 | 235 | 0.03373000 | 235 | 236 | 0.03373000 | 236 | 237 | 0.03373000 |
| 237 | 238 | 0.03373000 | 238 | 239 | 0.03373000 | 239 | 240 | 0.03373000 |
| 240 | 241 | 0.03373000 | 241 | 242 | 0.03373000 | 242 | 243 | 0.03373000 |
| 243 | 244 | 0.03373000 | 244 | 245 | 0.03373000 | 245 | 246 | 0.03373000 |
| 246 | 247 | 0.03373000 | 247 | 248 | 0.03373000 | 249 | 250 | 0.03373000 |
| 250 | 251 | 0.03373000 | 251 | 252 | 0.03373000 | 252 | 253 | 0.03373000 |
| 253 | 254 | 0.03373000 | 254 | 255 | 0.03373000 | 255 | 256 | 0.03373000 |
| 256 | 257 | 0.03373000 | 257 | 258 | 0.03373000 | 258 | 259 | 0.03373000 |
| 259 | 260 | 0.03373000 | 260 | 261 | 0.03373000 | 261 | 262 | 0.03373000 |
| 262 | 263 | 0.03373000 | 263 | 264 | 0.03373000 | 264 | 265 | 0.03373000 |
| 215 | 232 | 0.13494000 | 232 | 249 | 0.13494000 | 216 | 233 | 0.13494000 |
| 233 | 250 | 0.13494000 | 217 | 234 | 0.13494000 | 234 | 251 | 0.13494000 |
| 218 | 235 | 0.13494000 | 235 | 252 | 0.13494000 | 219 | 236 | 0.13494000 |
| 236 | 253 | 0.13494000 | 220 | 237 | 0.13494000 | 237 | 254 | 0.13494000 |
| 221 | 238 | 0.13494000 | 238 | 255 | 0.13494000 | 222 | 239 | 0.13494000 |
| 239 | 256 | 0.13494000 | 223 | 240 | 0.13494000 | 240 | 257 | 0.13494000 |
| 224 | 241 | 0.13494000 | 241 | 250 | 0.13494000 | 225 | 242 | 0.13494000 |

TABLE A1 (continued)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 230 | 247 | 0.13494000 | 247 | 264 | 0.13494000 | 231 | 248 | 0.13494000 |
| 17 | 34 | 0.03373000 | 18 | 35 | 0.05397000 | 50 | 51 | 0.03373000 |
| 35 | 52 | 0.05397000 | 34 | 51 | 0.05397000 | 51 | 68 | 0.05397000 |
| 67 | 68 | 0.13494000 | 52 | 69 | 0.05397000 | 68 | 85 | 0.05397000 |
| 84 | 85 | 0.03373000 | 69 | 86 | 0.05397000 | 85 | 102 | 0.05397000 |
| 102 | 119 | 0.03373000 | 103 | 120 | 0.05397000 | 119 | 136 | 0.05397000 |
| 135 | 136 | 0.03373000 | 120 | 137 | 0.05397000 | 136 | 153 | 0.05397000 |
| 153 | 170 | 0.03373000 | 154 | 171 | 0.05397000 | 170 | 187 | 0.05397000 |
| 186 | 187 | 0.03373000 | 171 | 198 | 0.05397000 | 187 | 214 | 0.05397000 |
| 213 | 214 | 0.13490000 | 198 | 215 | 0.05397000 | 214 | 231 | 0.05397000 |
| 248 | 265 | 0.13490000 | 18 | 266 | 0.11800000 | 35 | 267 | 0.02950000 |
| 52 | 268 | 0.11800000 | 69 | 269 | 0.02950000 | 86 | 270 | 0.11800000 |
| 103 | 271 | 0.11800000 | 120 | 272 | 0.02950000 | 137 | 273 | 0.11800000 |
| 154 | 274 | 0.11800000 | 171 | 275 | 0.02950000 | 198 | 276 | 0.11800000 |
| 34 | 277 | 0.11800000 | 51 | 278 | 0.02950000 | 68 | 279 | 0.11800000 |
| 85 | 280 | 0.02950000 | 102 | 281 | 0.11800000 | 119 | 282 | 0.11800000 |
| 136 | 283 | 0.02950000 | 153 | 284 | 0.11800000 | 170 | 285 | 0.11800000 |
| 187 | 286 | 0.02950000 | 214 | 287 | 0.11800000 | 266 | 267 | 0.14300000 |
| 267 | 268 | 0.14300000 | 268 | 269 | 0.14300000 | 269 | 270 | 0.14300000 |
| 270 | 271 | 0.10930000 | 271 | 272 | 0.14300000 | 272 | 273 | 0.14300000 |
| 273 | 274 | 0.10730000 | 274 | 275 | 0.14300000 | 275 | 276 | 0.14300000 |
| 277 | 278 | 0.14300000 | 278 | 279 | 0.14300000 | 279 | 280 | 0.14300000 |
| 280 | 281 | 0.14300000 | 281 | 282 | 0.10930000 | 282 | 283 | 0.14300000 |
| 283 | 284 | 0.14300000 | 284 | 285 | 0.10930000 | 285 | 286 | 0.14300000 |
| 286 | 287 | 0.14300000 | 277 | 300 | 0.66600000 | 287 | 300 | 0.66600000 |
| 266 | 300 | 0.66600000 | 276 | 300 | 0.66600000 | 251 | 300 | 0.00324000 |
| 252 | 300 | 0.00324000 | 253 | 300 | 0.00324000 | 254 | 300 | 0.00324000 |

# TABLE A2

QGEN TABLE = WATTS (OR TEMP FOR BOUNDARY NODES)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | 0.0156 | 3 | 0.0156 | 4 | 0.0040 | 5 | 0.0040 |
| 7 | 0.0050 | 8 | 0.0050 | 9 | 0.0100 | 10 | 0.0100 |
| 11 | 0.0030 | 12 | 0.0030 | 13 | 0.0120 | 14 | 0.0120 |
| 15 | 0.0050 | 16 | 0.0050 | 20 | 0.0500 | 21 | 0.0250 |
| 22 | 0.0260 | 23 | 0.0260 | 24 | 0.0500 | 25 | 0.0010 |
| 26 | 0.0125 | 27 | 0.0250 | 28 | 0.0250 | 29 | 0.0375 |
| 30 | 0.0375 | 31 | 0.0170 | 53 | 0.0400 | 54 | 0.0400 |
| 55 | 0.0020 | 56 | 0.0020 | 75 | 0.0006 | 76 | 0.0006 |
| 77 | 0.0006 | 78 | 0.0006 | 79 | 0.0006 | 80 | 0.0006 |
| 81 | 0.0006 | 82 | 0.0006 | 83 | 0.0006 | 84 | 0.0006 |
| 121 | 0.0006 | 122 | 0.0006 | 123 | 0.0006 | 124 | 0.0006 |
| 125 | 0.0006 | 126 | 0.0006 | 127 | 0.0006 | 128 | 0.0006 |
| 129 | 0.0006 | 130 | 0.0006 | 131 | 0.0006 | 132 | 0.0006 |
| 133 | 0.0006 | 134 | 0.0006 | 135 | 0.0006 | 172 | 0.0006 |
| 173 | 0.0006 | 174 | 0.0006 | 175 | 0.0006 | 176 | 0.0006 |
| 177 | 0.0006 | 178 | 0.0006 | 179 | 0.0006 | 180 | 0.0006 |
| 181 | 0.0006 | 182 | 0.0006 | 183 | 0.0006 | 184 | 0.0006 |
| 185 | 0.0006 | 186 | 0.0006 | 236 | 0.0430 | 237 | 0.0260 |
| 239 | 0.0050 | 241 | 0.0050 | 245 | 0.0380 | 246 | 0.0760 |
| 247 | 0.0150 | 300 | 100.0000 | 0 | 0. | 0 | 0. |

# TABLE A3

## CALCULATED TEMPERATURES

## FOR PWB A1

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ( 1) | 108.567 | ( 2) | 109,401 | ( 3) | 110.256 | ( 4) | 110.828 | ( 5) | 111,309 | ( 6) | 111,655 | ( 7) | 111,940 | ( 8) | 112, |
| ( 9) | 112.046 | ( 10) | 111.879 | ( 11) | 111.487 | ( 12) | 111.008 | ( 13) | 110.417 | ( 14) | 109,536 | ( 15) | 103,472 | ( 16) | 107, |
| ( 17) | 106.822 | ( 18) | 105.234 | ( 19) | 107.731 | ( 20) | 109.816 | ( 21) | 110,782 | ( 22) | 111.447 | ( 23) | 111,896 | ( 24) | 112, |
| ( 25) | 111.830 | ( 26) | 111,778 | ( 27) | 111,757 | ( 28) | 111.530 | ( 29) | 111,154 | ( 30) | 110,360 | ( 31) | 109,057 | ( 32) | 107, |
| ( 33) | 105,957 | ( 34) | 104.049 | ( 35) | 105.774 | ( 36) | 107.717 | ( 37) | 109.174 | ( 38) | 109,928 | ( 39) | 110,425 | ( 40) | 110, |
| ( 41) | 110,927 | ( 42) | 110.828 | ( 43) | 110,743 | ( 44) | 110.615 | ( 45) | 110,349 | ( 46) | 109,918 | ( 47) | 109,222 | ( 48) | 108, |
| ( 49) | 107,076 | ( 50) | 105.814 | ( 51) | 104.396 | ( 52) | 106.435 | ( 53) | 106.008 | ( 54) | 108,972 | ( 55) | 109,233 | ( 56) | 109, |
| ( 57) | 109.705 | ( 58) | 109,817 | ( 59) | 109.817 | ( 60) | 109.733 | ( 61) | 109.560 | ( 62) | 109.272 | ( 63) | 108,847 | ( 64) | 106, |
| ( 65) | 107.530 | ( 66) | 106,681 | ( 67) | 105.768 | ( 68) | 104.844 | ( 69) | 106.354 | ( 70) | 107,295 | ( 71) | 107,993 | ( 72) | 108, |
| ( 73) | 108,664 | ( 74) | 108.865 | ( 75) | 108,992 | ( 76) | 109.014 | ( 77) | 108,948 | ( 78) | 108,792 | ( 79) | 108,536 | ( 80) | 108. |
| ( 81) | 107,690 | ( 82) | 107.106 | ( 83) | 106,447 | ( 84) | 105.752 | ( 85) | 105,066 | ( 86) | 106,200 | ( 87) | 106,732 | ( 88) | 107, |
| ( 89) | 107.586 | ( 90) | 107.871 | ( 91) | 108.072 | ( 92) | 108.193 | ( 93) | 108,229 | ( 94) | 108,181 | ( 95) | 108,049 | ( 96) | 107, |
| ( 97) | 107.527 | ( 98) | 107,142 | ( 99) | 106.691 | (100) | 106.197 | (101) | 105,693 | (102) | 105,221 | (103) | 105,711 | (104) | 106. |
| (105) | 106,377 | (106) | 106.681 | (107) | 106.935 | (108) | 107.128 | (109) | 107,253 | (110) | 107,308 | (111) | 107,292 | (112) | 107, |
| (113) | 107,015 | (114) | 106.819 | (115) | 106.534 | (116) | 106.200 | (117) | 105,835 | (118) | 105,465 | (119) | 105.121 | (120) | 105, |
| (121) | 105,600 | (122) | 105.934 | (123) | 106,241 | (124) | 106,502 | (125) | 106,705 | (126) | 106,842 | (127) | 106,913 | (128) | 106, |
| (129) | 106,851 | (130) | 106,721 | (131) | 106,527 | (132) | 106,274 | (133) | 105,968 | (134) | 105,623 | (135) | 105,258 | (136) | 104, |
| (137) | 104,775 | (138) | 105.122 | (139) | 105.470 | (140) | 105.792 | (141) | 106,068 | (142) | 106,284 | (143) | 106,436 | (144) | 106, |
| (145) | 106,543 | (146) | 106.501 | (147) | 106.398 | (148) | 106.234 | (149) | 106.009 | (150) | 105,724 | (151) | 105,386 | (152) | 105, |
| (153) | 104.629 | (154) | 103.849 | (155) | 104.352 | (156) | 104.833 | (157) | 105.259 | (158) | 105.609 | (159) | 105.872 | (160) | 106, |
| (161) | 106.153 | (162) | 106.197 | (163) | 106.108 | (164) | 106.127 | (165) | 106,011 | (166) | 105,825 | (167) | 105,548 | (168) | 105, |
| (169) | 104,640 | (170) | 104.046 | (171) | 103.136 | (172) | 103.925 | (173) | 104,573 | (174) | 105,114 | (175) | 105.543 | (176) | 105, |
| (177) | 105.939 | (178) | 106,075 | (179) | 106.113 | (180) | 106.120 | (181) | 106.097 | (182) | 106,044 | (183) | 105.939 | (184) | 105, |
| (185) | 105.311 | (186) | 104.606 | (187) | 103.613 | (198) | 102.499 | (199) | 103,549 | (200) | 104.343 | (201) | 105.000 | (202) | 105, |
| (203) | 105.823 | (204) | 105.938 | (205) | 105.989 | (206) | 106.012 | (207) | 105.032 | (208) | 106.049 | (209) | 106,072 | (210) | 106, |
| (211) | 106.000 | (212) | 105,609 | (213) | 104.714 | (214) | 103.316 | (215) | 103.298 | (216) | 103,816 | (217) | 104.452 | (218) | 10[illegible] |
| (219) | 106,105 | (220) | 106.255 | (221) | 106,045 | (222) | 105,974 | (223) | 105,916 | (224) | 105,954 | (225) | 105.984 | (226) | 10[illegible] |
| (227) | 106,456 | (228) | 107,042 | (229) | 107.165 | (230) | 106.082 | (231) | 105,102 | (232) | 103,487 | (233) | 103.893 | (234) | 104, |
| (235) | 105.256 | (236) | 106.520 | (237) | 106.537 | (238) | 106.051 | (239) | 105,964 | (240) | 105,855 | (241) | 105,925 | (242) | 105, |
| (243) | 106,110 | (244) | 106.541 | (245) | 107.576 | (246) | 108.088 | (247) | 106,603 | (248) | 105,572 | (249) | 103,576 | (250) | 103, |
| (251) | 104.425 | (252) | 105.185 | (253) | 106.158 | (254) | 106.277 | (255) | 105,557 | (256) | 105.833 | (257) | 105.748 | (258) | 10[illegible] |
| (259) | 1[illegible].828 | (260) | 106.027 | (261) | 105.474 | (262) | 107.278 | (263) | 107,589 | (264) | 106,630 | (265) | 105,783 | (266) | 101, |
| (267) | 103.329 | (268) | 104.974 | (269) | 105.414 | (270) | 105.660 | (271) | 105.399 | (272) | 104,943 | (273) | 104,421 | (274) | 103, |
| (275) | 102.095 | (276) | 100,641 | (277) | 100.915 | (278) | 102.589 | (279) | 103,890 | (280) | 104,405 | (281) | 104,782 | (282) | 104, |
| (283) | 104.555 | (284) | 104.238 | (285) | 103.400 | (286) | 102.226 | (287) | 100,765 | ( | | | | | |

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SUBJECT

MICROPUMP PRIMING

INFORMATION REQUESTED/RELEASED

OBJECT: To determine the self priming characteristics of the Micropump 04-71-303-1421 and to develop a suitable configuration to ensure pump priming in WCS usage.

PROCEDURE: With 1/8" i.d. tubing connect the pump outlet to a check valve and a water column so that the pump and outlet line remain dry. Determine the maximum pressure gradient against which the pump will pump air. Repeat this procedure after wetting the pump gears and draining. Connect a water reservoir to the inlet of the pump, using 3/16" i.d. tubing (see Figure 1). The inlet and outlet lines should be air filled. Determine the pressure gradient against which the pump will self prime.

Connect an air bypass line from the pump outlet back to the reservoir and determine the new priming characteristics of the system, by repeating the preceeding determination. Measure the influence of different size bypass lines by measuring flow rates through the outlet and bypass lines.

RESULTS:

| | |
|---|---|
| pump air-dried | pumps air against 12.5" $H_2O$ |
| pump wet, drained | pumps air against 15" $H_2O$ |
| Inlet 6" of 3/16" i.e. } air filled<br>Outlet 2" of 1/8" i.d. } | pump primes system against 14" $H_2O$ |
| 1/8" bypass line | pump primes against > 4' $H_2O$ |

| Bypass i.d. | Pumping rate | Bypass flow rate |
|---|---|---|
| .125" | 512 ml/min | 436 ml/min |
| .030 | 903 | 34 |

NOTE: Pumping rate does not include bypass flow.

CONCLUSIONS: The maximum pressure gradient against which the pump will self prime depends on the relative volumes of air in the inlet and outlet lines. If the air entrapped in the inlet line is of a small enough volume to be compressed into the volume of the outlet line prior to the check valve, at a pressure below 12.5" $H_2O$, then the system can prime itself. To ensure system priming against a positive pressure gradient, a bypass line from the pump outlet to the phase separator is recommended. Since prompt priming is achieved with a .125" i.d. bypass line, at the expense of a high bypass flow rate, and a low bypass flow rate is obtained with an .030" i.d. bypass, at the expense of an extended priming time, an intermediate size should be chosen for the bypass line.

cc: G. Fogal
J. Mangialardi

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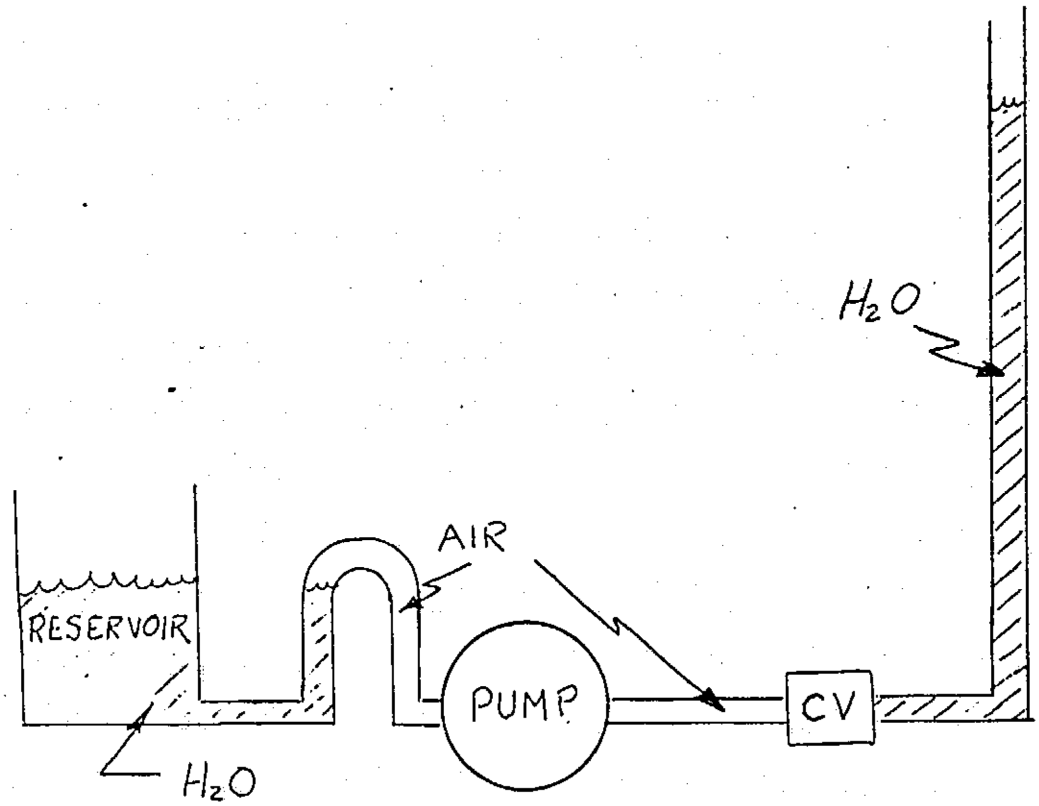


FIGURE 1 PRIMING TEST SET-UP

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| 7-23-75 | | BMS | |

SUBJECT

Test of Expansion Bladder Material

INFORMATION REQUESTED/RELEASED

## A. INTRODUCTION

The flush water tank needs an expansion bladder to minimize the build up of internal pressure due to thermal expansion of water in the aluminum shell at temperatures up to 150°F.

The general requirements for the bladder were established in PIR 1R60-75-144 and are:

Type: Close Cell Foam Rubber
Working Volume: 200 $cm^3$ at Ambient Pressure
Performance: Compress by 27.13 $cm^3$ when pressurized from 17 PSIG to 30 PSIG

The 17 PSIG level represents the maximum filling pressure from the water supply. The 30 PSI is a conservative working limit for the tank. The 27.13 $cm^3$ compression is required to accommodate the maximum expansion of the water in the filled tank.

## B. DESCRIPTION OF TEST

A sample piece of soft foam rubber with close cell structure has been obtained from the Stockwell Rubber Company and has been tested for conformance to our requirements.

The sample piece is in the form of a strip, has a volume of 44.43 $cm^3$ and is identified by Stockwell as SR-11-N, MIL-R-6130 B, Type 2, Grade A, Soft.

The rubber strip was placed in a small sealed test chamber filled with water and connected to a pump as shown on the following page.

The tests runs were made in two steps:

1. The test chamber was pressurized by operating the pump with valve A open, valve B closed, and using valve C to control the pressure at the desired level.

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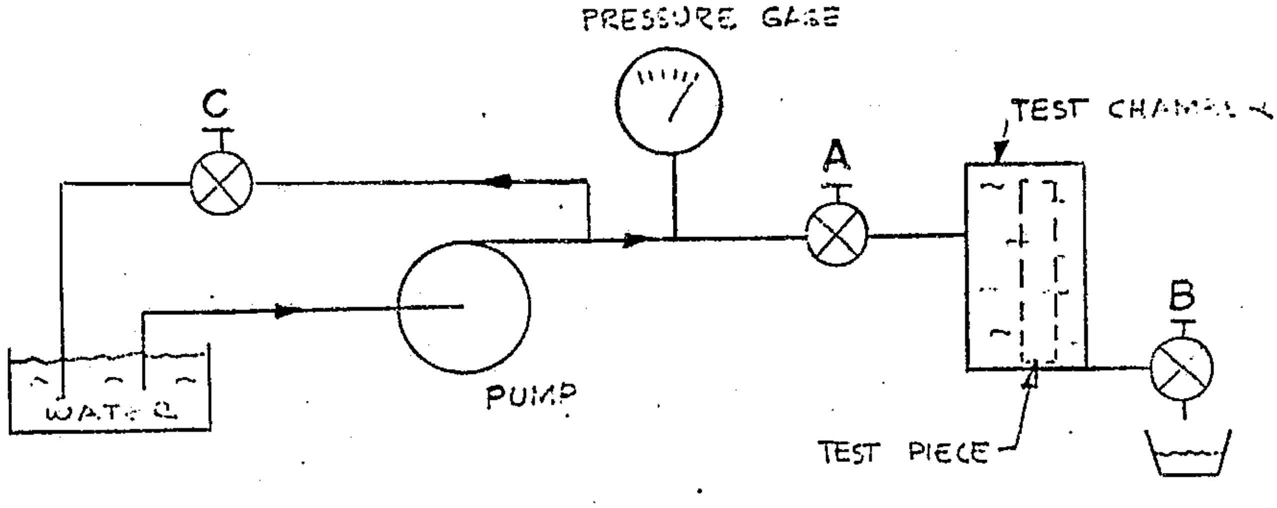
FORM 1020 B REV. (9-70)




TEST SETUP

2. Valve A was closed, valve B was opened and the effluent water was collected in a beaker and measured. The weight represented the volume that the rubber had compressed at the set pressure. Note that for water 1 gm $\approx$ 1 $cm^3$.

   Additional test runs were made using the same procedure after removing the sample piece from the test chamber to establish a correction factor for the elasticity chamber itself without the foam rubber.

   The test results are summarized and plotted in the attached Figure 1.

C. CONCLUSION

The test sample was compressed by 5.5 $cm^3$ when pressurized from [illegible] to 30 PSIG. If instead of making a special bladder we use the commercially available material tested, the equivalent total volume required is:

$$V = 44.43\ cm^3 \times 27.13\ cm^3 / 5.5\ cm^3 = 219\ cm^3$$

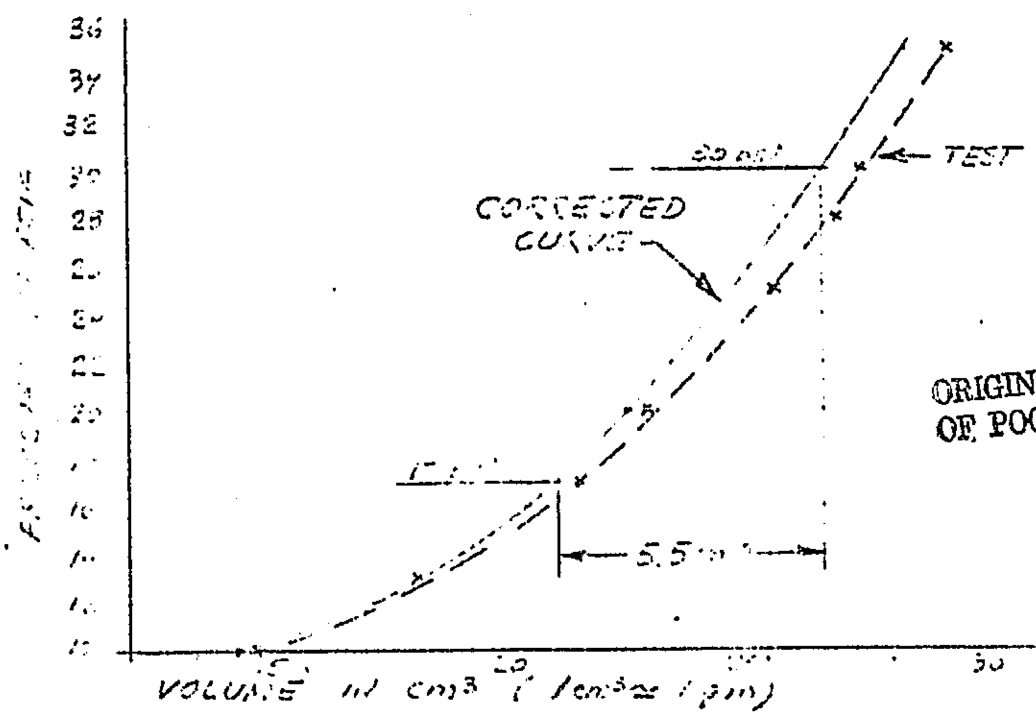
which is quite close to the ideal 200 $cm^3$ calculated in the referenced PIR.

As suggested, the foam rubber will be added in the form of two longitudinal strips bonded to the inside of the aluminum shell. This arrangement has the obvious advantage of eliminating the long term effect of water permeation, or loss of performance due soaking through broken, if the foam rubber were to be used as a bladder inside the main bladder as originally planned. The strips will also work as air channels for internal venting between the bladder and the tank wall.

SUMMARY OF TEST DATA

| PRESSURE PSI | WEIGHT OF WATER OUT - GRAMS TOTAL | - CONTAINER | = NET |
|---|---|---|---|
| 35 | 32.8 | 3.7 | 29.1 |
| 30 | 31.0 | 3.7 | 27.3 |
| 28 | 30.5 | 3.7 | 26.8 |
| 25 | 29.2 | 3.7 | 25.5 |
| 23 | 28.3 | 3.8 | 24.5 |
| 20 | 26.3 | 3.4 | 22.9 |
| 17 | 25.2 | 3.7 | 21.5 |
| 13 | 21.8 | 3.7 | 18.1 |
| 10 | 18.1 | 3.4 | 14.7 |
| 30 * | 4.4 | 3.5 | 0.9 |
| 20 * | 4.5 | 3.8 | 0.7 |
| 10 * | 4.2 | 3.8 | 0.4 |

* TEST CHAMBER WITHOUT FOAM RUBBER STRIP




COMPRESSION OF FOAM RUBBER STRIP
STOCKWELL RUBBER ...

FIGURE 1 - SUMMARY OF TEST RESULTS

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| 8-1-75 | | | |

SUBJECT

DESIGN OPTIMIZATION OF BMS SEPTA

INFORMATION REQUESTED/RELEASED

OBJECT: To evaluate various materials and determine the optimum choice for the septum for the urine sampling part in the BMS.

PROCEDURE: Several septa were made of each material to be evaluated. The needle insertion force was determined several times with a Hunter force guage, for each septum. The septa were then subjected to a cyclic life test as described in PIR 133 of 5-15-75. Each septum was tested for 500 cycles or until failure. Plexiglass holders of .428 and .421 diameter were used, depending on results of needle insertion force tests and initial leak tests. Following testing of several septa of RTV700 and of RTV620, the in-house mold was polished and the corners rounded. More septa were then fabricated and tested.

The materials evaluated were:

RTV630
RTV700 } fabricated in-house

Modified RTV
DPR242 rubber
Vinyl plastisol } fabricated by DeBell & Richardson

Distribution: G. Fogal
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| ☐ | ☐ DO NOT DESTROY |

FORM 1020B REV. (9-70)

Insertion Force Test Results:

| Septum | Material | Holder dia. (in.) | Force (lb.) |
|---|---|---|---|
| 1 | DB & R modified RTV | .421 | 10.2 |
| 2 | DB & R DPR 242 | .421 | 5.8 |
| 3 | DB & R Vinyl plastisol | .421<br>.428 | 7.0<br>4.4 |
| 4,5,6 | GE RTV 700 | .421 | 6.3,5.2 |
| 17 | GE RTV 700<br>(polished mold) | .421<br>.428 | 3.2<br>6.1 |
| 10 | GE RTV 630 (a) | .428<br>.421 | 9.8<br>12.3 |
| 11 | GE RTV 630 (b) | .428<br>.421 | 6.8<br>10.1 |
| 13, 14 | GE RTV 630 (c) | .428<br>.421 | 5.6<br>11.6 |
| 15,16,18 | GE RTV 630 (c)<br>(W/polished mold) | .428 | 7.3,9.8 |

Life Test Results:

| Septum | Material | Holder dia. (in.) | Results |
|---|---|---|---|
| 4 | RTV 700 | .421 | stopped test @ 114 cycles due to septum wear |
| 6 | RTV 700 w/teflon sprayed needle | .421 | worn @ 122 cycles, stop @ 519 worn, no leakage |
| 8 | RTV 700 w/teflon sprayed needle | .421 | 243 cycles - slightly worn<br>555 cycles - stop test - worn & torn but no leakage |
| 9 | RTV 700 | .421 | 102 cycles |
| 10 | RTV 630 (a) | .421 | 252 cycles - worn, leaking, stop test |
| 11 | RTV 630 (b) | .421 | 72 cycles - wearing, no leak<br>500 cycles - worn, no leak, stop test |
| 12 | RTV 630 (b) | .421 | 250 cycles - leaking |
| 13 | RTV 630 (c) | .421 | 21 cycles - stop test as needle will not retract properly |
| 14 | RTV 630 (c) | .428<br>.421 | leaks<br>won't work |
| 15 | RTV 630 (c) polished mold | .428 | 516 cycles - no signs of wear no leak |
| 16 | RTV 630 (c) polished mold | .428 | 566 cycles - no signs of wear no lead |
| 17 | RTV 700 polished mold | .421 | 340 some sign of wear, no leak<br>362 leaks<br>543 leaks badly, stop test septum torn |
| 18 | RTV 630 (c) | .428 | 504 cycles - no wear, no leak, stop test |

Conclusion: RTV 630, in a 10:1 ratio of compound to catalyst, cured for two hours at 200°F results in a satisfactory septum. Difficulties were encountered due to the unpolished condition of the mold - polishing and rounding sharp edges made a significant improvement in the quality of the septum produced. These septa did not leak under pressure and showed no signs of abrasive wear after more than 500 needle insertion/withdrawl cycles. They did exhibit a tendency to allow a small quantity of water to cling to the needle as it was withdrawn, but their superior wear resistance is considered to be more important.

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| F. Drummond<br>Room U2439, X4659 | J. Mangialardi<br>Room U1243 |

| DATE SENT | DATE INFO. REQUIRED | PROJECT AND REQ. NO. | REFERENCE DIR. NO. |
|---|---|---|---|
| 8/6/75 | | | |

SUBJECT

THERMAL ANALYSIS OF BMS ASSEMBLY

INFORMATION REQUESTED/RELEASED


## SUMMARY

On the basis of continuous operation of the BMS for 1.0 hour, or 12 cycles, the maximum component temperatures were:

| | |
|---|---|
| Phase Separator Drive Motor | 80°C |
| Urine Pump | 69 |
| Flush Pump | 38 |
| A1 Logic Card - Electronics | 48 |
| Power Supply - Electronics | 108 |


## 1.0 INTRODUCTION

The BMS assembly is a mechanism for obtaining urine samples from the crew of the shuttle. Figure 1 is an exploded schematic of the assembly. Heat dissipation in the BMS is located in the phase separator drive motor, the urine pump, the flush pump and the electronics. The duty cycle of the equipment is shown on Figure 2. This figure gives a cycle time of 300 secs. Since no realistic duty cycle, or frequency of operation, is available, Mr. John Mangialardi suggested 1 hour of continuous operation.

## 2.0 REQUIREMENTS

The limiting temperature requirements for the critical items of the BMS assembly are shown on Table 1.

Table 1

BMS Critical Temperature Requirements

| | |
|---|---|
| Phase Separator Motor | 130°C |
| Urine Pump Motor | 90°C |
| Flush Pump Motor | 90°C |
| A1 Logic Card | 125°C |
| Power Supply | 125°C |

~~G. Fogal U1240~~
J. Billings U2446
V. Young U2446
S. Peck U4212
L. Blomstrom U2439

PAGE NO. ___ OF ___

RETENTION REQUIREMENTS

| COPIES FOR | MASTERS FOR |
|---|---|
| ☐ 1 MO. | ☐ 3 MOS. |
| ☐ 3 MOS. | ☐ 6 MOS. |
| ☐ 6 MOS. | ☐ 12 MOS. |
| ☐ MOS. | ☐ MOS. |
| ☐ | ☐ DO NOT DESTROY |

FORM 1020B REV. (9-70)

PIR: U-1R54-1092
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## 3.0 MODEL DESCRIPTION

A 28 node model was developed for the BMS. Table 2 lists the nodal elements and describes them. Table 3 presents the math model input data to the computer. A conductivity of 90 Btu/hrft°F was used for the aluminum and a conductance of 68.0 Btu/hrft$^2$°F was assumed for joints. During operation of the phase separator an air flow rate of 8 cfm passes through the separator. For the first 100 seconds of operation urine at 98°F is assumed in contact with the phase separator walls. Connection to the air is 1.43 Btu/hr°F and to the urine is 10.0 Btu/hr°F. No convection from the outer surface of the assembly to the shuttle environment is included nor is any conduction to the shuttle structure. These assumptions were made because ther is no established provision to install the BMS in the shuttle.

## 4.0 ANALYSIS

In the performance of the heat up of the BMS the heat inputs were average values for a cycle except for the convection between the urine (node 28) and the phase separator body. This heat exchange was restricted to the first 100 seconds of a cycle with none in the subsequent 200 seconds. Convection to the air (node 20) followed an inverse pattern. A total of 12 cycles were run, for a total time of 1 hour.

## 5.0 RESULTS AND DISCUSSION

Table 4 presents the final temperatures of all the elements of the model. Figure 3 is a plot of the heat dissipating elements of the model. Note that node 14 is the housing for the electronics and not the parts themselves. Shown separately on Table 3 are the logic card maximum temperatures and the power supply maximum temperatures. These temperatures are based on the temperature rises above the environment calculated separately for these components. The calculations for the card are contained in Reference 1 and in the appendix for the power supply.

Referring to Table 4 and Figure 3 it is seen that none of the calculated temperatures exceed the allowable limits. It should be noted however that:

> This analysis provides only "worst case" heat up characteristics, but no cool down characteristics. It is reasonable to assume that the BMS will be bolted into the shuttle and will be "bathed" in the shuttle environment. Therefore when the BMS is not in use it will tend to return to the ambient temperature level of the shuttle.

NODAL TEMPERATURES IN DEG-[illegible]

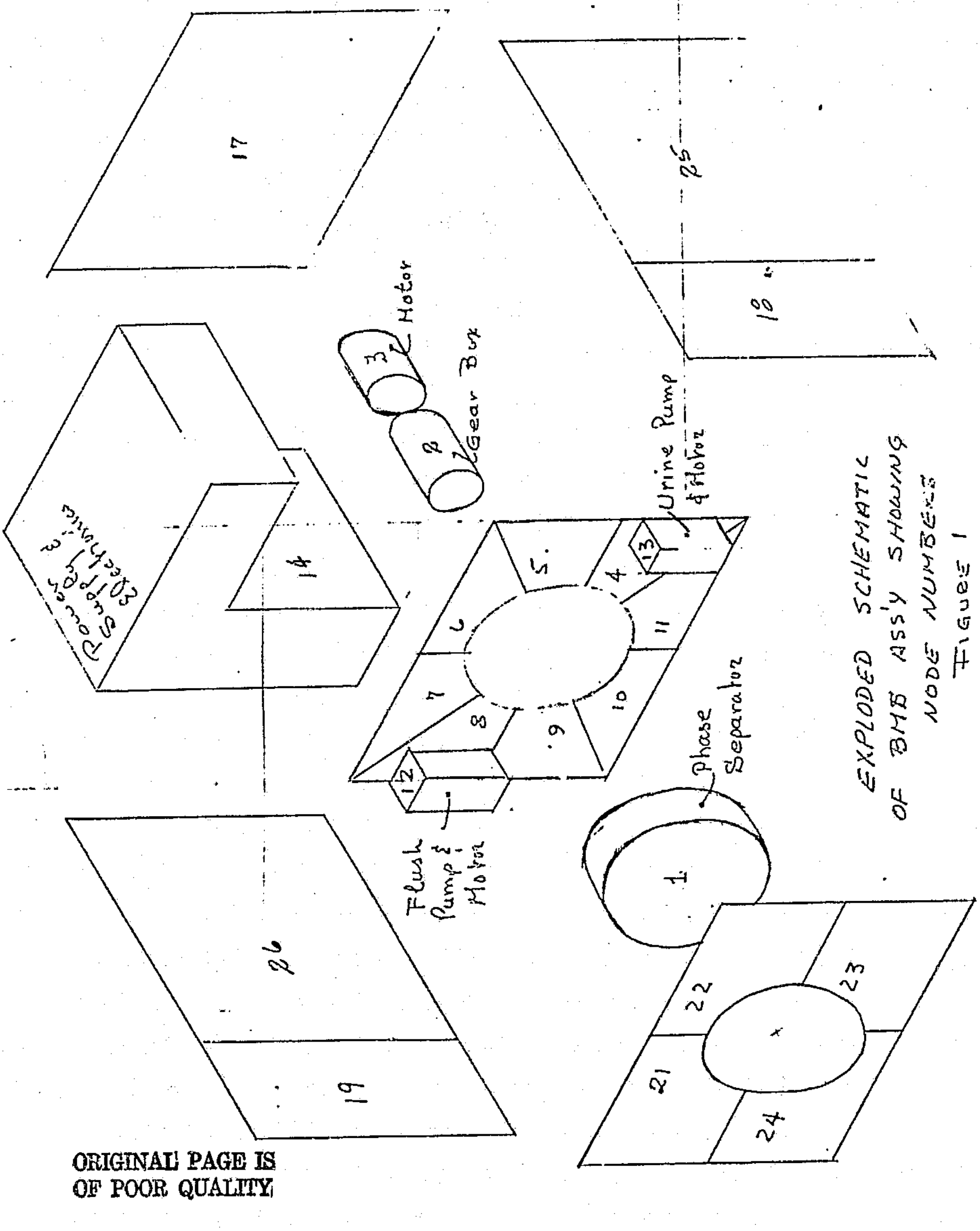
Logic Card - 48
Power Supply - 108

Table 4

TIME= 105.000 ( 0. )

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 33.93 | 2 | 37.83 | 3 | 79.32 | 4 | 53.13 |
| 5 | 43.35 | 6 | 33.34 | 7 | 37.83 | 8 | 37.73 |
| 9 | 33.53 | 10 | 40.41 | 11 | 45.75 | 12 | 37.55 |
| 13 | 34.13 | 14 | 33.34 | 15 | 37.34 | 16 | 23.83 |
| 17 | 33.34 | 18 | 42.14 | 19 | 35.33 | 20 | 30.11 |
| 21 | 33.34 | 22 | 33.34 | 23 | 33.34 | 24 | 33.34 |
| 25 | 32.12 | 26 | 35.27 | 27 | 35.12 | 28 | 37.30 |

(15, 27 top, not shown)
(16, Bottom, not shown)




EXPLODED SCHEMATIC
OF BMB ASS'Y SHOWING
NODE NUMBERS
FIGURE 1

Est. System Operating Time for 300 avg. Micturition

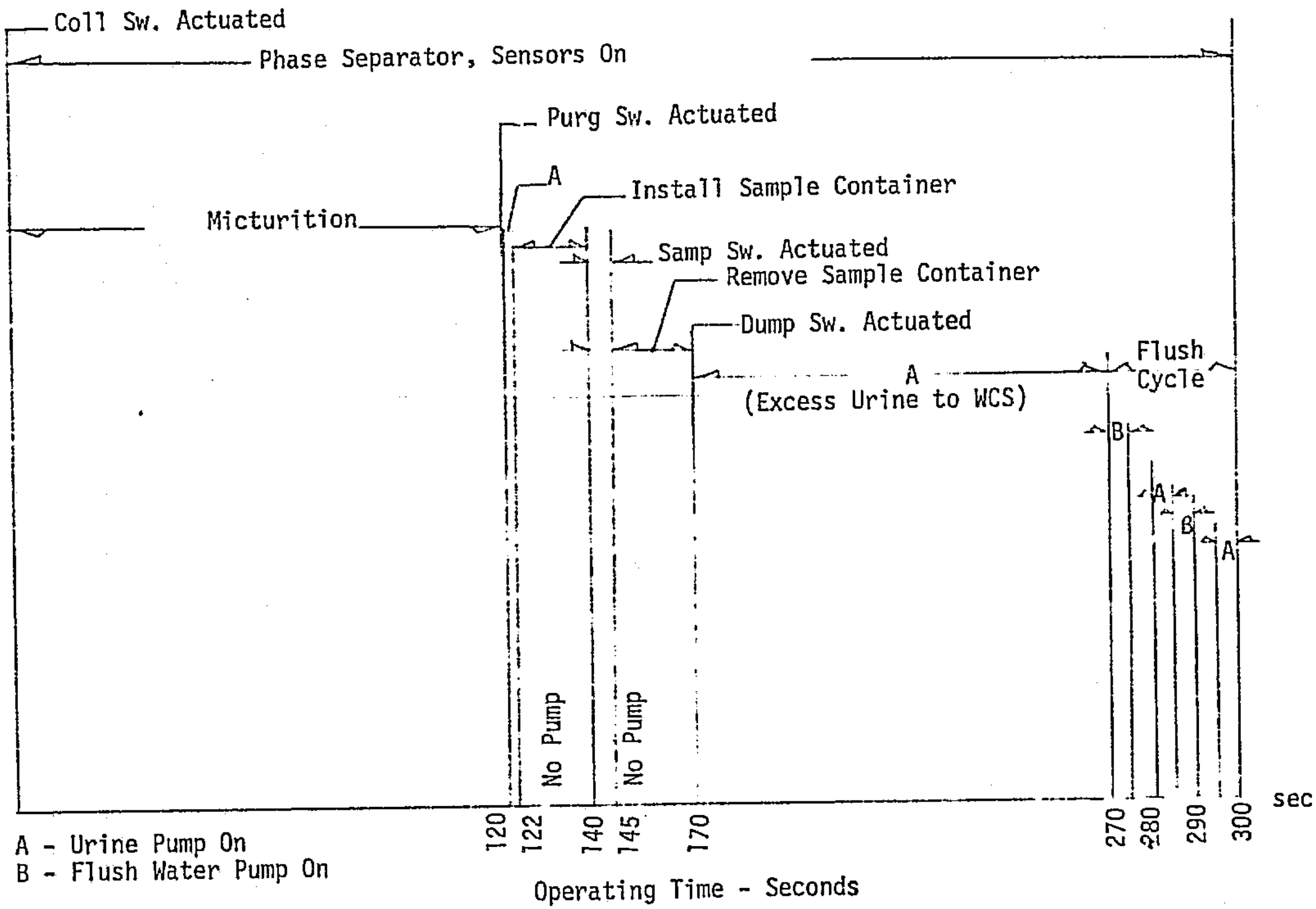



Figure 2

Table 2

Node Description

| Node Number | Description |
|---|---|
| 1 | Phase Separator Body |
| 2 | Gear Box, Phase Separator |
| 3 | Motor, Phase Separator |
| 4-11 | Central Mounting Plate |
| 12 | Flush Pump and Motor |
| 13 | Urine Pump and Motor |
| 14 | Power Supply & Electronics Ass'y |
| 15 | Housing Top, Front |
| 16 | Housing, Bottom |
| 17 | Housing, Rear Surface |
| 18 | Housing, Right Side, Front |
| 19 | Housing, Left Side, Front |
| 20 | Cooling Air, (Boundary Node) |
| 21-24 | Housing Front |
| 25 | Housing, Right Side, Rear |
| 26 | Housing, Left Side, Rear |
| 27 | Housing, Top, Rear |
| 28 | Urine (Boundary Node) |

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OF POOR QUALITY

Table 3

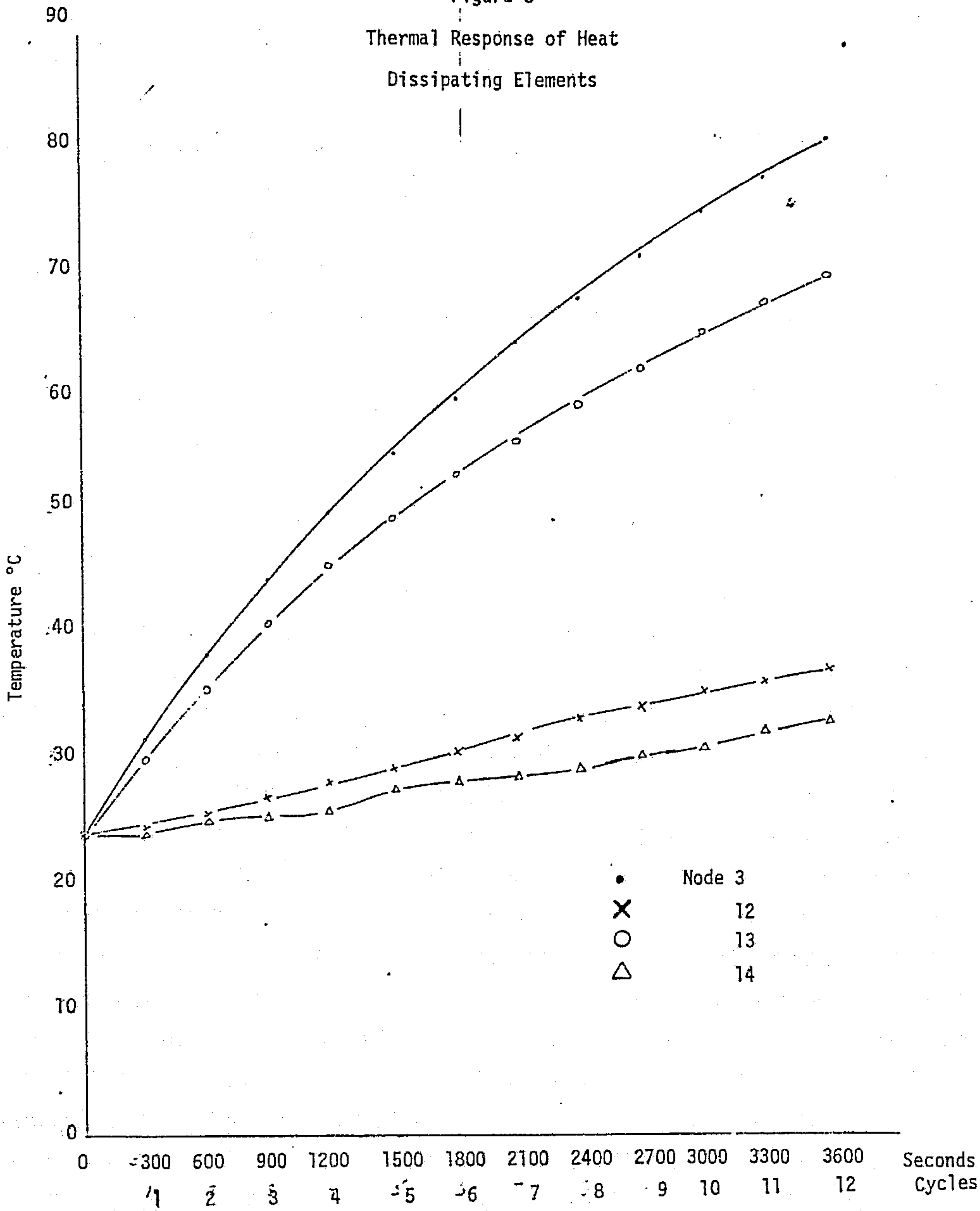
Computer Input

| | |
|---|---|
| 2[illegible], 2, 15.0, 15.0, 105., 105., 105., NO, NO, 0 | Model Size and Time Limits |
| 2[illegible], 23 | Boundary Nodes |
| 57 | |
| 1, 4, 0.27, 1, 5, 0.27, 1, 6, 0.2, 1, 7, 0.2, 1, 8, 0.27, 1, 9, 0.27 | |
| 1, 10, 0.2, 1, 11, 0.2, 1, 2, 0.914, 2, 3, 1.137, 3, 12, 1.361, 4, 13, 1.361 | |
| 4, 5, 0.412, 5, 6, 0.492, 6, 7, 0.412, 7, 8, 0.492, 8, 9, 0.412, 9, 10, 0.492 | |
| 10, 11, 0.412, 1, 21, 1.634, 1, 22, 1.634, 1, 23, 1.634, 1, 24, 1.634, 9, 19, 0.316 | |
| 3, 19, 0.316, 4, 13, 0.316, 5, 13, 0.316, 19, 26, 0.75, 13, 25, 0.75, 15, 27, 0.150 | Conduction Network |
| 21, 22, 0.344, 22, 23, 0.344, 23, 24, 0.344, 21, 24, 0.344 | |
| 21, 19, 0.583, 24, 19, 0.583, 22, 13, 0.583, 23, 13, 0.583, 21, 15, 0.733 | |
| 22, 15, 0.733, 7, 15, 0.433, 6, 15, 0.433, 7, 27, 0.1633, 6, 27, 0.1633, 15, 13, 0.0393 | |
| 25, 27, 0.141, 15, 19, 0.0393, 26, 27, 0.141, 17, 25, 0.779, 17, 26, 0.779, 17, 27, 0.343 | |
| 4, 11, 1.492, 12, 14, 0.333, 14, 27, 1.094, 14, 26, 0.267, 1, 20, 1.486 | |
| 1, 23, 12. | |
| 0 | |
| 0 | |
| 0 | |
| 0 | |
| 3, 38.425, 12, 4.5, 13, 37.23, 14, 17.25, 22, 545.6, 23, 553.54 | Heat Dissipation |
| -1 | |
| 27 | |
| 1, [illegible], 2, 0.33, 3, 0.33, 4, 0.0182, 5, 0.0182, 6, 0.0182, 7, 0.0182, 8, 0.0182 | |
| 9, [illegible], 10, 0.0182, 11, 0.0182, 12, 0.243, 13, 0.243, 14, 1.24, 15, 2.2392 | Heat Capacitance |
| 16, 0.1[illegible]7, 17, 0.127, 18, 0.0392, 19, 0.0392, 20, 3.547, 21, 0.0136, 22, 0.0136 | |
| 23, 0.[illegible], 24, 0.0137, 25, 0.2534, 26, 0.2534, 27, 0.2534 | |

Figure 3

Thermal Response of Heat

Dissipating Elements



PIR: U-1R54-1092
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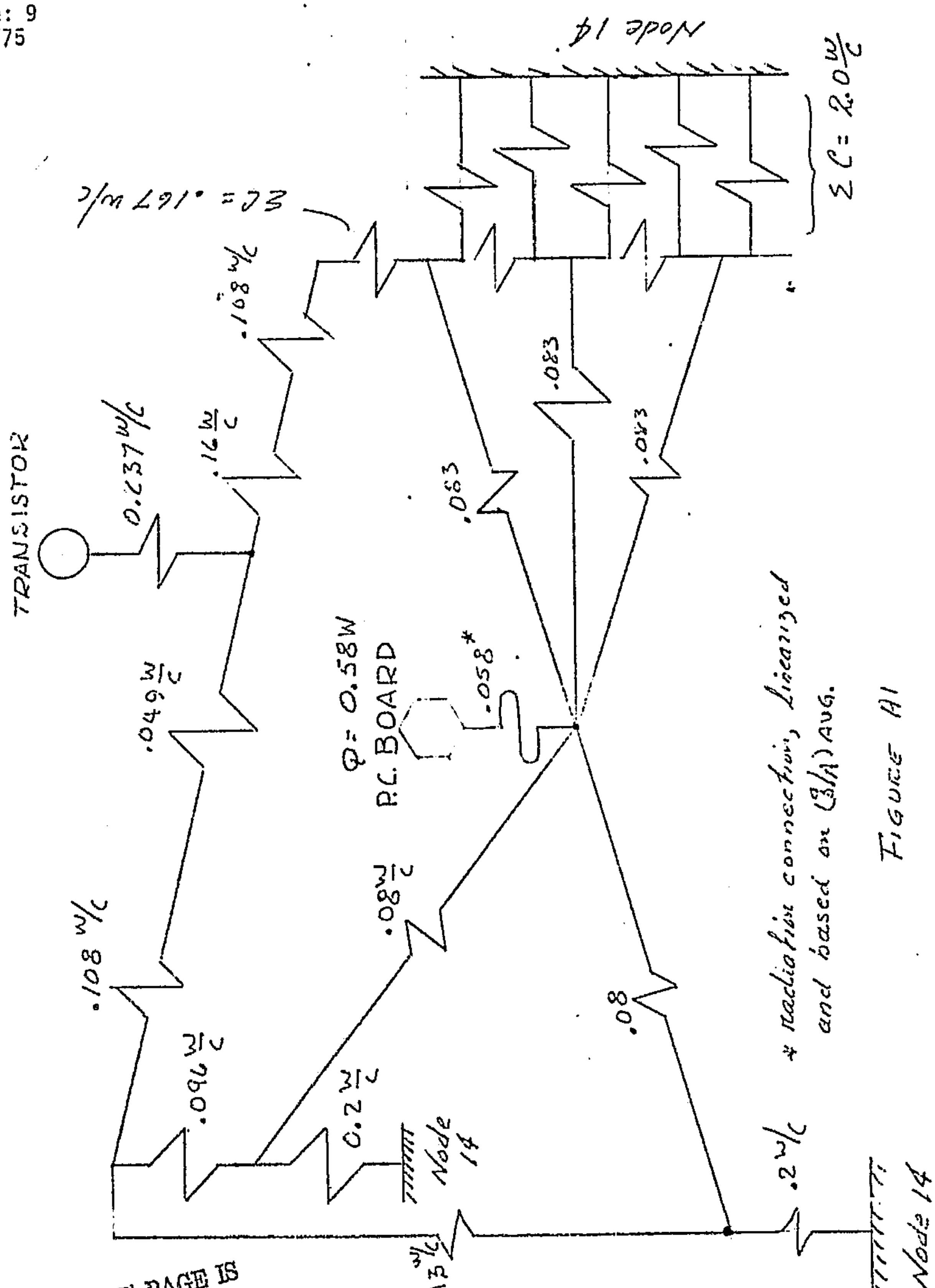
8/6/75

## Appendix

The attached data show (Figure A1) the electric analog model of the power supply of BMS and (Figure A2) the detail element temperatures of the logic card.

The analysis performed for the power supply network shown on Figure 1A included the Power Supply PWB as a lumped man element, dissipating 0.58W ~ uniformly. Subsequent discussions with Steve Peck have shown that the dissipation can vary from 0.814W to 1.055W. The average Q/A for the PWB (Q = .814) is 50.8 mw/in$^2$ while discrete locations (CR2-CR7) is 336.8 mw/in$^2$, and the A2 Hybrid is 390.6 mw/in$^2$. At this stage of the analysis it is not possible to perform a detailed analysis of the PWB assembly. Therefore, the average PWB temperature was determined and the local temperature determined by Q/A ratios. These temperatures are shown in Table 1A. It should be noted that no conduction in the board was considered except locally and neither was conduction from the board to the box through the mounting screws. These effects will tend to reduce local temperatures but not more than 10 - 15°C.

In reviewing this assembly, the fact that this assembly will be located in a pressurized environment. Therefore, conduction through the air will assist in cooling the PWB. However, since there is no "g" field there will be no convection. Air conduction and radiation to a relatively low environmental temperature will compensate for the poor conduction in the board, poor contact of the components with the board, and the relatively isolated mounting of the board.




* radiation connection, linearized and based on (σ/A) AVG.

FIGURE A1

ANALOG NETWORK OF POWER SUPPLY

Table 2A

PREDICTED PERFORMANCE OF SIGNIFICANT PARTS

| Piece Part | Tsink °F/°C | Δt1 °F/°C | Δt2 °C | Δt3 °C | Tmax °F/°C |
|---|---|---|---|---|---|
| A49 - Urine Pump Relay Driver | * | 9.8/5.4 | .13 | 4.68 | 41.2 |
| A50 - Flush Pump Relay Driver | | 11.05/6.14 | .03 | 1.2 | 38.4 |
| A29 - Sample Lamp, Driver | | 11.96/6.64 | .04 | 1.5 | 39.2 |
| A30 - Dump Switch Lamp Driver | | 11.96/6.64 | .08 | 3.0 | 40.7 |
| A31 - Flush "On" Lamp Driver | | 11.2/6.2 | .025 | 0.9 | 38.1 |
| A32 - Sample Collect Lamp Driver | | 9.9/5.5 | 0.1 | 3.6 | 40.2 |
| A51 - Sample Container Lamp Driver | | 8.0/4.4 | .04 | 1.5 | 36.9 |
| A33 - Power/Phase Separator Relay Drive | | 8.45/4.7 | .34 | 12.0 | 48. |
| A35 - S.C. ID. Sensor Bias Relay | | 9.36/5.2 | .017 | .6 | 36.8 |
| R1 - Resistor | | 7.42/4.0 | .01 | - | 35. |
| Integrated Circuit Logic | | 9.0/5.0 | <.01 | ∿.1 | 36.1 |

(1) Tmax = Tsink + Δt1 + Δt2 + Δt3

Δt1 - temperature rise of piece part above case.

Δt2 - temperature difference, PCB to piece part case.

Δt3 - temperature rise of PCB under piece part above sink.

*From Figure 3, the sink temperature of Node 14 is 31°C.

TABLE II

POWER SUPPLY PWB TEMPERATURES

| Component | Dissipation (each, mw)* | Dissipation Total, mw | Heated Area, $in^2$ | Q/A $mw/in^2$ | Q/AL Q/AT | ΔTL | Tmx Local |
|---|---|---|---|---|---|---|---|
| CR1A/1B | 151 | 302 | 0.472 | ~640. | 9.7 | 65.4 | 105.4 |
| CR2A12B | 10 | 384 | 0.57 | 673. | 10.2 | 68.8 | 108.8 |
| CR3A/3B | 10 | | | | | | |
| CR4/5/6/7 | 86 | | | | | | |
| A3 | 28 | 28 | .585 | 47.8 | .7 | 4.7 | 44.7 |
| A4 | 1 | 1 | .431 | - | - | - | - |
| T2 | 390 | 390 | 1.56 | 250. | 3.79 | 25.6 | 65.6 |
| T1 | 5 | 5 | .562 | - | - | - | - |
| A1 | 110 | 110 | .64 | ~172 | 2.61 | 17.6 | 57.6 |
| A2 | 264 | 264 | .64 | 412.5 | 6.25 | 42.2 | 82.2 |

*Worst Case, 1055 mw Total; Q/A (Avg.) = 65.9 $mw/in^2$; $\overline{\Delta T}$ pwb - env = 67.5°L

IMC MAGNETICS CORP., Executive Offices, 570 Main Street, Westbury, New York 11591 • (516) 334-7070
• TWX (510) 222-4469

May 21, 1975

General Electric Company
P.O. Box 8555
Philadelphia, PA 19101

Attention: John K. Mangialardi, Room U-1243, VFSC

Subject: Phase Separator Drive Motor IMC P/N BT 2910G-2

Reference: G.E. Purchase Order 028-S41027
IMC W.O. X3144

Dear John:

Enclosed please find the speed-torque data on the Phase Separator Drive Motor.

The outline drawing has also been corrected to reflect the motor which we are supplying to you. Please note that the current is 0.3 amps rather than the 0.7 amps previously stated. The 0.7 amps was based on a 115 volts line to line winding.

The unit will be shipped to your shortly.

If you have any questions, please do not hesitate to call me.

Very truly yours,

IMC MAGNETICS CORP.

Robert Altschuler

Robert Altschuler
Sr. Project Engineer

RA/ds
Encls.

cc: J. Pinner
G. Egan
F. Fisher
Mesa Technical

ORIGINAL PAGE IS OF POOR QUALITY

Westbury, New York • Rochester, New Hampshire • Maywood, California • Tempe, Arizona

Temp. Rise with
C.H. @ N.L.=41°C

TEST DATA

| V | A | W1 | W2 | Wt | T | N | WOUT | WLOSS | HP | %EFF |
|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 0.25 | 37.5 | -17.5 | 20 | 0 | 5950 | | | | |
| | 0.27 | 42 | -14 | 26 | 2 | 5900 | 8.73 | 17.3 | .011 | 31.2 |
| | 0.29 | 49 | -11 | 38 | 4 | 5850 | 17.3 | 20.7 | .023 | 45.6 |
| | 0.30 | 54 | -7 | 47 | 6 | 5800 | 25.7 | 21.3 | .034 | 54.6 |
| | 0.33 | 60 | -4 | 56 | 8 | 5700 | 33.7 | 22.3 | .045 | 59.2 |
| | [illegible] | [illegible] | 0 | 68 | 10 | 5500 | 40.7 | 27.3 | .054 | 59.8 |
| | 0.42 | 75 | 1 | 76 | 11 | 5200 | [illegible] | 33 | .058 | 56.7 |
| | 0.62 | 96 | -23 | 73 | 7.4 | 0 | | | | |
| WITH 14.945 GEAR RATIO | | | | | | | | | | |
| 200 | 0.29 | 45 | -12 | 33 | 30 | 390 | 14.4 | 18.6 | | 43.7 |
| 200 | | | | | 105 | 0 | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| [illegible]-21/50 | 200 | 0.3 | 400 | 3 | 5300 / 388 | 8 | T.E. | Cont. | Rev. [illegible] | [illegible]/72 |

**MICROPUMP**

PARTS LIST NO. 1421

PART NO. 80221

DATE January 19, 1975

REV January 19, 1975

TEST SPECIFICATION 1421

MODEL NO. 04-71-303-1421

CUSTOMER REF General Electric Co.

SERIAL NO. 1063

TEST FLUID Water

TEMPERATURE 70°-80° F.

POWER 200 V. 400~ 3Ø

TEST

1. PROOF PRESSURE: WHEN PRESSURIZED WITH AIR @ 40 PSIG MIN., PUMP DRIVEN ASSEMBLY (P/N 80182) MUST NOT LEAK WHEN HELD UNDER WATER FOR A TWO (2) MINUTE TEST PERIOD. NOT MORE THAN ONE (1) MINUTE SETTLING TIME IS ALLOWED BEFORE TEST PERIOD.

DATE OF TEST April 3-75

PASSED X FAILED

Gary Marteneau
SIGNATURE



MICROPUMP CORPORATION 1035 SHARY COURT, CONCORD, CALIF. 94518 (415) 687-0101

MICROPUMP

PARTS LIST NO. 1421

PART NO. 80221

DATE January 19, 1975

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DATE OF TEST April 3-75

PASSED X FAILED ____

Gary Martineau
SIGNATURE



MICROPUMP CORPORATION 1035 SHARY COURT, CONCORD, CALIF. 94518 (415) 687-0101

2. STARTING CURRENT: WITH PUMP & MOTOR CONNECTED FOR NORMAL OPERATION, STARTING CURRENT SHALL NOT EXCEED 0.9 AMPS. AND SHALL DROP TO NORMAL OPERATING (.55 AMP. MAX.) WITHIN 2 SECONDS.

STARTING CURRENT .4 AMPS

AFTER 2 SECONDS .2 AMPS

DATE OF TEST April 3 75

PASSED X FAILED

Gary Martineau
SIGNATURE

3. NORMAL OPERATION: FLUID TEMP. 72°

| | PRESS. | | FLOW | CURRENT | | | POWER | P.F. |
|---|---|---|---|---|---|---|---|---|
| | IN | OUT | | P-1 | P-2 | P-3 | | |
| REQ'D | 0 | 0 | 50gph | -- | - | - | — | - |
| ACTUAL | 0 | 0 | 52 G.p.H | .2 | .2 | 2 | 33 | .4< |

DATE OF TEST April 3 75

PASSED X FAILED

Gary Martineau
SIGNATURE

4. DIALECTRIC STRENGTH

1000 VOLTS, 60 CYCLES, FOR ONE (1) SEC. (RATE OF APPLICATION 500 V/SEC)

LEADS ABC (TIED TOGETHER) TO FRAME Motor in pump SN #1063

DATE OF TEST 3 April 75

PASSED ✓ FAILED ____

Tom [illegible]
SIGNATURE

5. INSULATION RESISTANCE

500 VOLTS + 10% D.C., RESISTANCE MUST EXCEED 500 MEGOHMS

LEADS ABC (TIED TOGETHER) TO FRAME Motor in pump SN #1063

DATE OF TEST 3 April 75

PASSED ✓ FAILED ____

Tom [illegible]
SIGNATURE

POST TEST OPERATIONS:

DRAIN PUMP

SEAL PORTS WITH CAPLUG "K-5"

MICROPUMP

TEST

04-71-303-1421     S/N 1062

(G.E. PHILADELPHIA ) VALLEY FORGE

1. TEST USING WATER @ 100°F.
2. 200 V., 400 V., 3Ø
3. MEASURE FLOW AT 16 PSI 18 GPH
3a. MEASURE FLOW AT 4 PSI 22 GPH
4. WHAT PRESSURE (MAX.) FOR 300 CC/MIN. 72 PSI
5. MUST NOT DECOUPLE AT BLOCKED FLOW.
6. PRESSURE AT BLOCKED FLOW 96 PSI
7. WATTS @ 15 PSI 35

Bob Otten by orw

BOB OTTEN

10/2/75

DATE

GLOBE MOTOR 33A2217A

22000/5500 RPM

16 - 40 WATTS

200V 400 HZ 3Ø

MODEL 204 PRESSURE TRANSDUCER

OPERATING INSTRUCTIONS

## GENERAL INFORMATION

Your Setra transducer has been carefully calibrated before shipment to you, and it should be handled with the same care given any precision instrument. Pressure range and dimensions are reported on the specifications bulletin for the transducer.

## AMBIENT CONDITIONS

Do not use in ambient conditions corrosive to anodized aluminum, or submerged in liquids or subjected to spray or drip. The unit is not designed for use in very high vibration environment.

## ATMOSPHERIC REFERENCE (Gage pressure transducers only).

Lower range units are subject to excessive thermal zero shift unless vented to atmosphere. The electrical cable provides this equalization vent. Do not seal the electrical cable when installing. Fluids or gases other than clean dry air should not be allowed to enter the cable.

## ELECTRICAL CONNECTIONS:

| Cable Lead | Function |
|---|---|
| White | positive excitation |
| Yellow | positive output |
| Brown | negative output |
| Black | negative excitation |
| Shield | case |

## ELECTRICAL

The pressure transducer must be operated with the case connected either to the negative excitation terminal or to the negative output terminal. Failure to do this may result in damage to or unsatisfactory operation of the unit. This connection may be made by connecting shield and back (-excitation) leads or shield and brown leads together. Most effective shielding against noise will be obtained by using the shield and -excitation leads.

Circuit is reversed voltage protected for at least 5 minutes. Internal transient suppression network is provided for short duration transients to 150 volts.

## ADJUSTMENTS

Remove cover of transducer to get access to adjustments.

### ZERO PRESSURE OUTPUT

Can be adjusted to zero by potentiometer as shown in diagram. Unit factory-adjusted to zero output.

### SENSITIVITY

Can be adjusted by potentiometer as shown on outline diagram. Unit factory-adjusted to order specification.

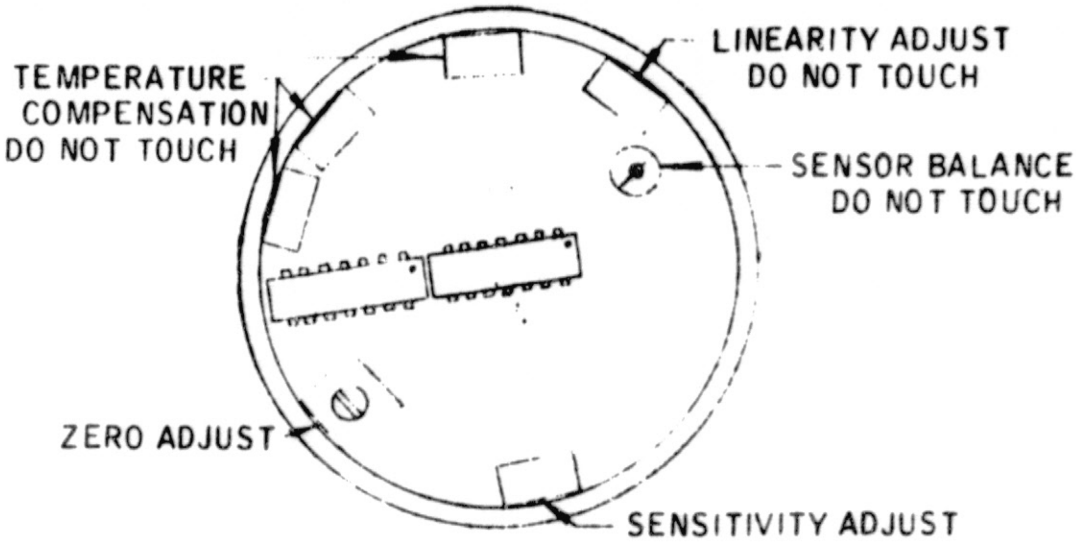
### LINEARITY DO NOT TOUCH

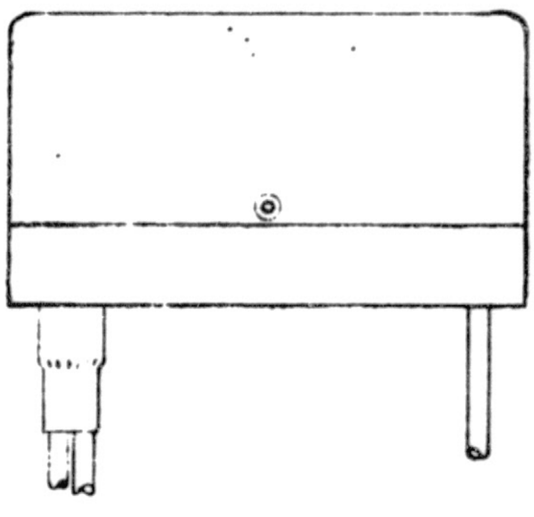
Factory-adjusted for best linearity. Touching any adjustments other than zero output or sensitivity may necessitate recalibration.

Rev. 4/75

12 Huron Drive, Natick, Massachusetts 01760 (617) 655-4645

Setra systems INC



| | | | |
|---|---|---|---|
| REVISIONS | | DRAWN | SETRA SYSTEMS, INC. |
| | | CHECKED | ADJUSTMENTS<br>MODEL 204 PRESSURE TRANSDUCER |
| | | APPROVED | For G.E. Spec #ER47C231818 — REV. |

11017CN

Setra systems

TRANSDUCER CALIBRATION CERTIFICATE

MODEL: 204 SER. NO.: 6196

PRESSURE RANGE: 0 TO 0.6 PSID

EXCITATION: 24 VOLTS D.C.

ZERO PRESSURE OUTPUT*: +15 mv

FULL RANGE SENSITIVITY*: 5.023 VOLTS

OUTPUT NOISE: 1.45 mv RMS

DATE OF INSPECTION: 6.16.75

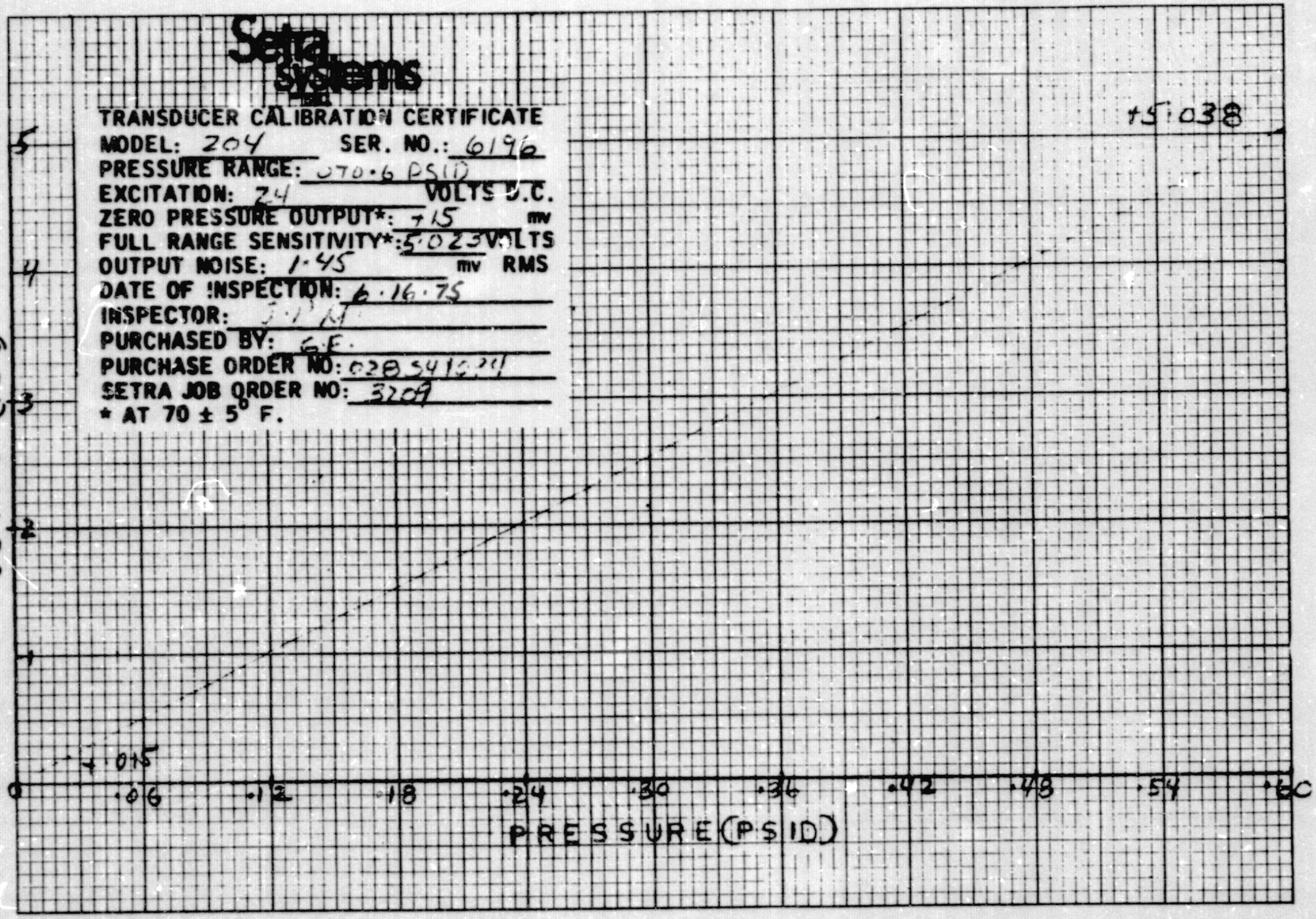
INSPECTOR: J.P.M.

PURCHASED BY: G.E.

PURCHASE ORDER NO: 028S41024

SETRA JOB ORDER NO: 3209

* AT 70 ± 5° F.




NE

## 6.3 Supplemental Fabrication Information

The following GE internal memo is intended to supplement/update previous data contained in the interim, PDR and/or CDR reports:

PIR 1R60-75-171, "Electrical Component Burn-In".

GENERAL ELECTRIC
SPACE DIVISION
PHILADELPHIA

# PROGRAM INFORMATION REQUEST / RELEASE

| | *CLASS. LTR. | OPERATION | PROGRAM | SEQUENCE NO. | REV. LTR. |
|---|---|---|---|---|---|
| PIR NO. | U | — 1R60 | — 75 | — 171 | |

*USE "C" FOR CLASSIFIED AND "U" FOR UNCLASSIFIED

FROM: V. P. Long, Room #U-2432, VFSC

TO: G. L. Fogal, Bioengineering Program Manager
Room #U-1240, VFSC

| DATE SENT | DATE INFO. REQUIRED | PROJECT AND REQ. NO. | REFERENCE DIR. NO. |
|---|---|---|---|
| 9-10-75 | | | |

SUBJECT: ELECTRICAL COMPONENT BURN - IN

INFORMATION REQUESTED/RELEASED

Since the BMS is a non-flight unit, it was decided to burn-in the majority of the components after board assembly during board checkout and system test. Most components are flat pack devices which are surface soldered and, therefore, easily removable, several components, however, have many leads which are inserted into the multilayer boards. Since these would be difficult to replace, it was decided to burn these in prior to board assembly.

One MN5203 A/D converter, two MN2002 references, two Spectrum Technology oscillators and nine DH006CH drivers fall into this category and were burned in as follows:

The A/D converter, references and oscillator were burned in for 336 hours at room temperature in a breadboard circiut exactly the same as the BMS printed wire boards. The DH0006CH relay drivers were tested in a special fixture, in which they drove a resistive load equivalent to the relay. These drivers were tested at room temperature for 168 hours. In addition one driver was connected to the exact type relay being driven and cycled 35,000 times with no effect on either the driver or the relay. This is greater by a factor of 10 than the expected use of the relay.

cc: G. L. Fogal (3)
A. Garawitz

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PAGE NO. 1 OF 1

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FORM 1023B REV. (9-70)

### 6.4 Test Report

PIR 1R60-75-XXX, "BMS Flight Prototype Test Results".

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| 12-8-75 | | Modular Biowaste Monitoring System | |

SUBJECT

BMS Flight Prototype Test Results

INFORMATION REQUESTED/RELEASED

1.0 SUMMARY

Operability of the BMS flight prototype model was demonstrated and operating performance data obtained using both urine and water as input fluids. No operational limitation were uncovered.

2.0 OBJECTIVE

Demonstrate operability of the BMS flight prototype model under both normal and contingency operating modes and obtain performance data.

3.0 TEST HARDWARE

BMS flight prototype, GE drawing ER47E231825, plus assoicated GSE hardware.

4.0 TEST DESCRIPTION

Tests of the flight prototype model were divided into four categories, i.e. operational procedures, volume measurement, sampling and mechanical/electronic. Specific tests and results are as described below.

4.1 Mission Operational Procedures

4.1.1 Normal Procedures

The integrated system test procedures as defined in the BMS OM and H Manual 75SDS4217, section 4.2.2. were successfully performed.

cc: G. L. Fogal (3)
V. P. Long
J. K. Mangialardi
R. W. Murray

PAGE NO. 1 OF 30

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| COPIES FOR | MASTERS FOR |
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FORM 1020 B REV. (9-70)

#### 4.1.2 Emergency Procedures

The contingency operating procedures as defined in the BMS OM and H Manual 75SDS4217, section 5.0 were successfully demonstrated.

### 4.2 Volume Measurement

#### 4.2.1 Calibration

Two calibration tests were performed. After completing the first calibration, subsequent tests indicated that the fluid residual in the phase separator could be substantially reduced by increased the pump-out time following each flush water input. To accomplish this reduction in residual, the pumpout time was increased from 6.4 to 33.6 seconds. The pressure sensor zero offset was also readjusted to the same offset value observed during the first calibration tests. However no change was made in the pressure sensor gain adjustment. A second calibration was then performed. Results of these two calibration tests are shown in table 1 and plotted in Figures 1 and 2. Figure 3 shows an example of the raw data obtained from the TLM output.

Inspection of Figure 1 shows that an approximate calibration may be achieved by use of four linear sections and deriving a fluid volume equation for each section. This was accomplished with results as shown in Tables 2 and 3. The fluid volume equations are based on the theoretical equation

$$V = k \left[\frac{P}{S\omega^2}\right]^X \qquad (1)$$

Where

V = Fluid volume
P = Pressure at phase separator periphery
$\omega$ = rpm of phase separator
S = Fluid specific gravity
X and k = Constants

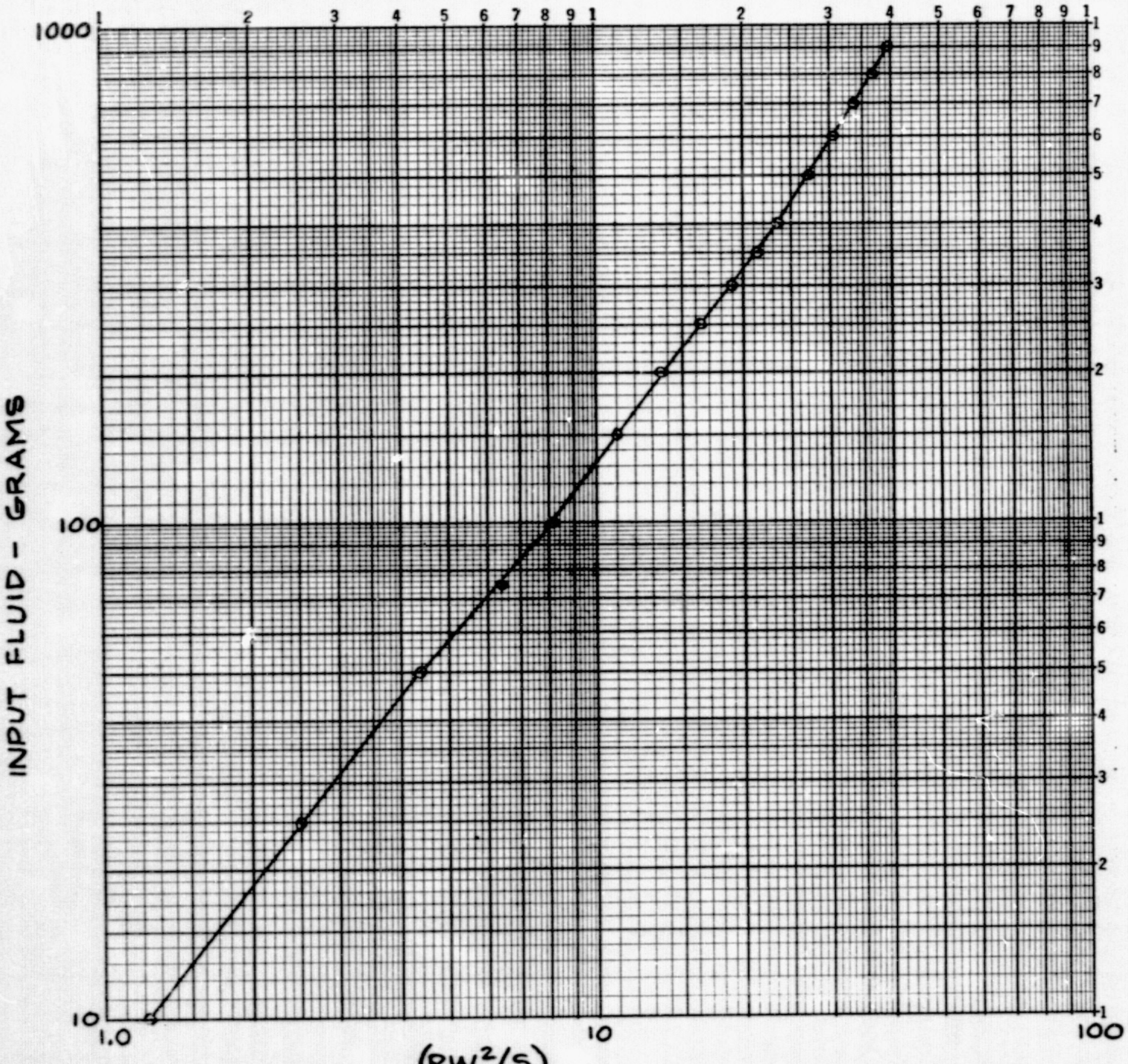



FIGURE 1(a) FIRST CALIBRATION TEST

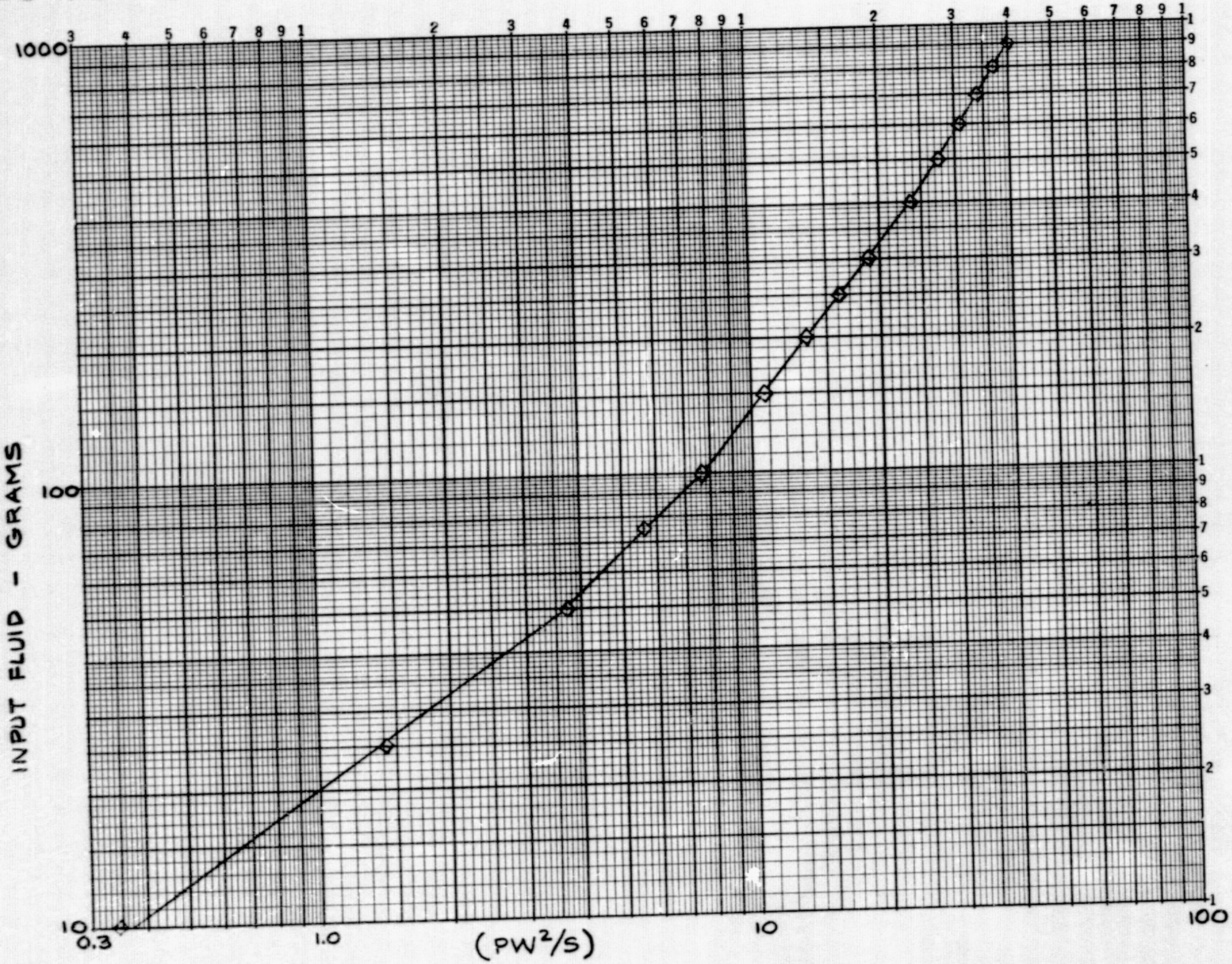



FIGURE 1 (b) SECOND CALIBRATION TEST

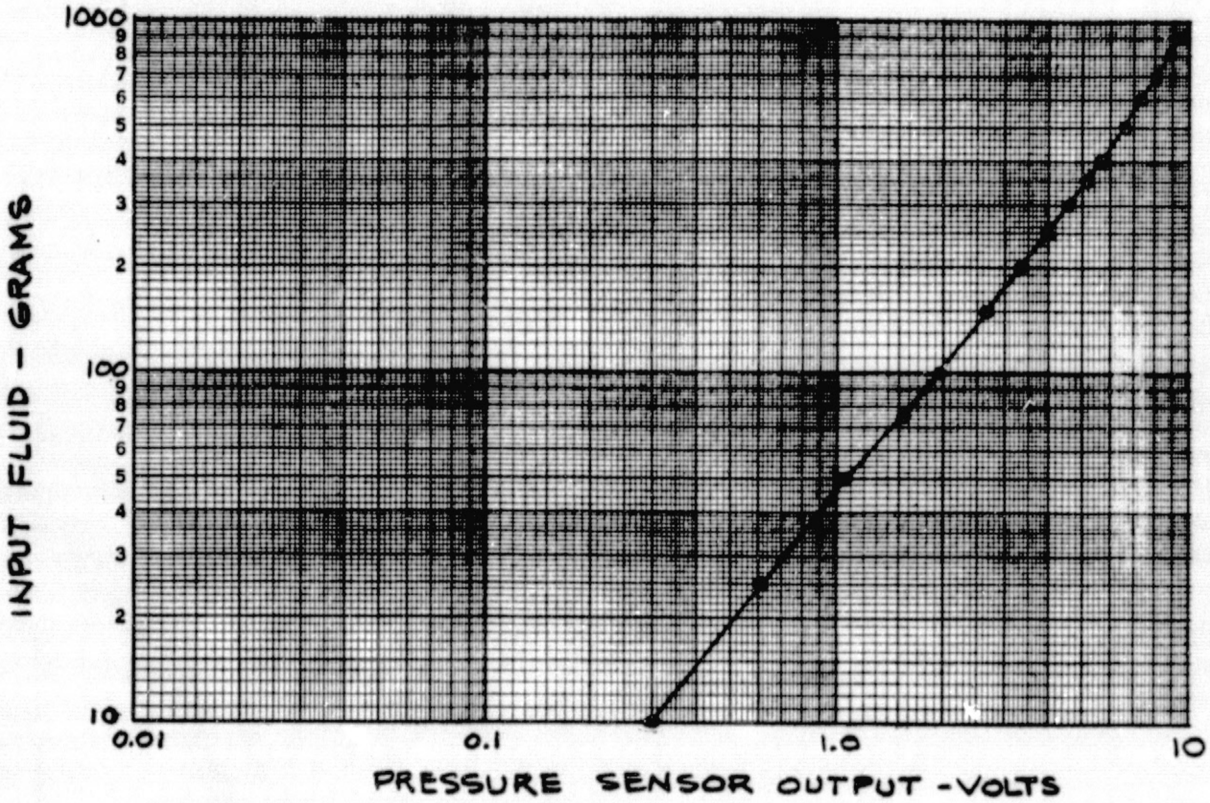



FIGURE 2(a) FIRST CALIBRATION TEST

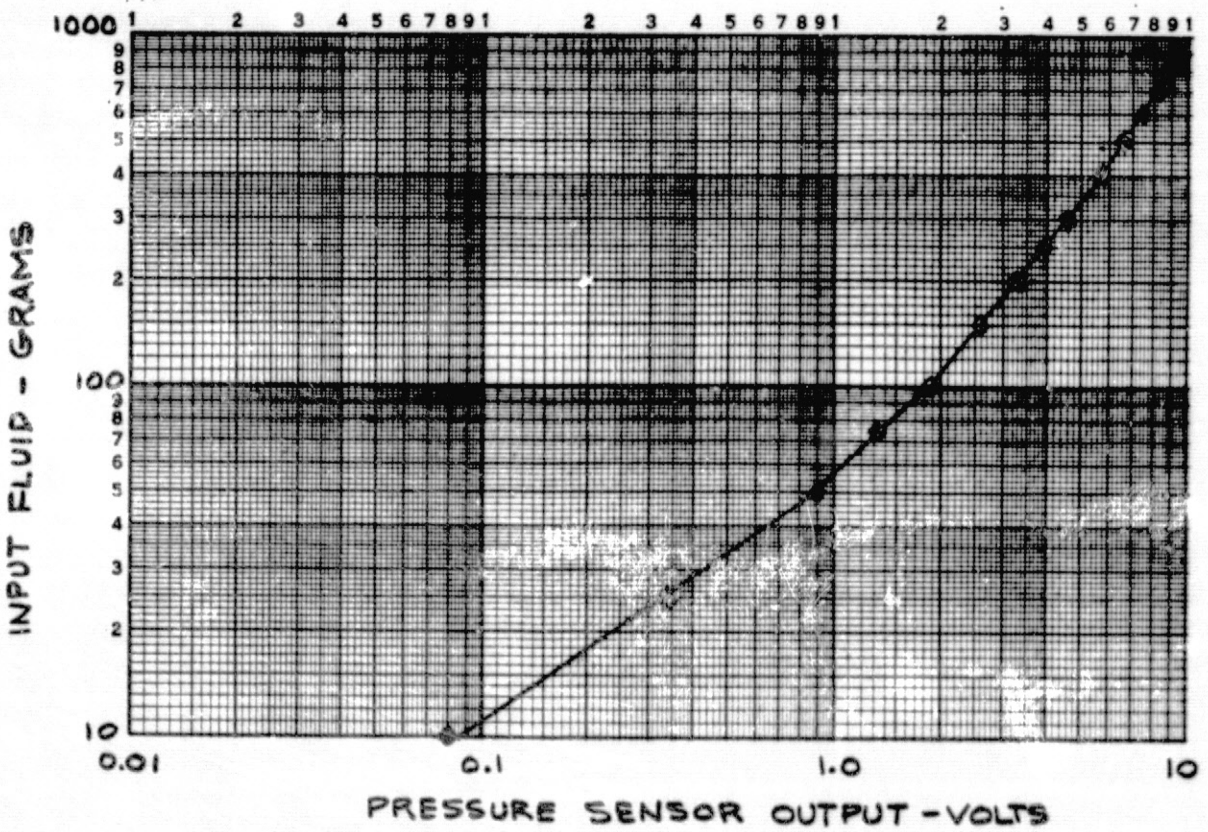



FIGURE 2(b) SECOND CALIBRATION TEST

```
      1055
      3178
      0000
--    0003
      1059
      3175
      0000
--    0002
      1061
      3178
      0000
--    0001
      1057
      3178
      0000
--    0007
      1061  <-- PRESSURE
      3177  <-- RPM
      0009  <-- SAMPLE CONTAINER NUMBER
--    0006  <-- USER ID
      1059
      3178
      0006
--    0005
      1062
      3178
      0000
--    0004
      1056
      3178
      0000
--    0003
      1059
      3177
      0000
--    0002
      1062
      3178
      0000
--    0001
```

FIGURE 3 TYPICAL TLM OUTPUT (ACTUAL TAPE RECORD, 150 GRAM INPUTS, SECOND CALIBRATION TEST)

Table 1 Calibration Test Data

| Test Sample Grams | $(PW^2/S)$[1] 1st Calibration Test | 2nd Calibration Test |
|---|---|---|
| 10 | 1.229 | 0.346 |
| 25 | 2.500 | 1.425 |
| 50 | 4.373 | 3.719 |
| 75 | 6.407 | 5.578 |
| 100 | 8.111 | 7.621 |
| 150 | 10.975 | 10.693 |
| 200 | 13.631 | 13.454 |
| 250 | 16.313 | 16.093 |
| 300 | 18.912 | 18.726 |
| 350 | 21.290 | ------ |
| 400 | 23.532 | 23.491 |
| 500 | 27.192 | 27.322 |
| 600 | 30.392 | 30.648 |
| 700 | 33.608 | 33.783 |
| 800 | 36.590 | 36.839 |
| 900 | 39.424 | 39.727 |

1. Mean value; based on 10 ambient temperature (70 to 75 °F) water samples and P and W equivalent pressure and rpm values $X10^{-3}$ are as recorded by the GSE printer via the BMS TLM output.

Table 2 Fluid Volume Equations, First Calibration Test

| Range | | Equation[1] |
|---|---|---|
| Volume | $\left[\frac{PW^2}{S}\right]$ | |
| 1. Under 50 ml | Under 4.4 | $V = 7.7 \left[\frac{PW^2}{S}\right]^{1.268}$ |
| 2. 50 to 100 ml | 4.4 to 8.1 | $V = 9.55 \left[\frac{PW^2}{S}\right]^{1.122}$ |
| 3. 101 to 425 ml | 8.1 to 24.5 | $V = 6.889 \left[\frac{PW^2}{S}\right]^{1.286}$ |
| 4. Over 425 ml | Over 24.5 | $V = 2.791 \left[\frac{PW^2}{S}\right]^{1.572}$ |

[1]Where

$V$ = Fluid volume in ml

$P$ = TLM output $X10^{-3}$ (pressure equivalent)

$W$ = TLM output $X10^{-3}$ (rpm equivalent)

$S$ = Specific gravity of fluid

Table 3 Fluid Volume Equations, Second Calibration Test

| Range | | Equation[1] |
|---|---|---|
| Volume | ($PW^2/S$) | |
| 1. Under 50 ml | Under 3.7 | $V = 20.53 \left[\frac{PW^2}{S}\right]^{0.6777}$ |
| 2. 50 to 100 ml | 3.7 to 7.6 | $V = 14.06 \left[\frac{PW^2}{S}\right]^{0.9661}$ |
| 3. 101 to 425 ml | 7.6 to 24.6 | $V = 8.188 \left[\frac{PW^2}{S}\right]^{1.232}$ |
| 4. Over 425 ml | Over 24.6 | $V = 2.778 \left[\frac{PW^2}{S}\right]^{1.57}$ |

[1]Where

V = Fluid volume in ml

P = TLM output $X10^{-3}$ (pressure equivalent)

W = TLM output $X10^{-3}$ (rpm equivalent)

S = Specific gravity of fluid

Table 4 Conversion Of TLM Outputs

RPM

$$\text{Phase separator RPM} = \frac{1250000}{\text{TLM rpm output}}$$

PRESSURE

$$\text{Pressure sensor voltage} = \frac{\text{TLM Pressure output}}{409.6}$$

Note: As adjusted by the vendor, a pressure sensor output of 10.00 volts corresponds to 0.6 psi. However, to compensate for a higher than anticipated pressure output, the pressure sensor gain was reduced. Thus as set for the second calibration test, a 10.00 volt output corresponds roughly to about 0.65 psi.

P and $\omega$ may be calculated from the TLM output (as shown in Table 4) or the TLM output may be used directly. Since the TLM output of rpm is actually proportional to $1/\omega$ then,

$$V = k^1 \left[\frac{PW^2}{S}\right]^x \qquad (2)$$

Where

P = TLM output (pressure equivalent)
W = TLM output (rpm equivalent)

For convenience, both P and W are divided by 1000.

The values of X in the fluid value equations, Tables 2 and 3, were calculated as in the following example (for Table 3, equation 4):

$$X = \frac{\log 900 - \log 500}{\log \left[\frac{PW^2}{S}\right]_{900} - \log \left[\frac{PW^2}{S}\right]_{500}} = \frac{0.25527}{0.16258} = 1.570$$

The value $k^1$ was then determined from equation (2) above. Thus

$$K' = \frac{V}{\left[\frac{PW^2}{S}\right]^x} = \frac{900}{(39.727)^{1.570}} = 2.778$$

and the equation (2) then becomes $V = 2.778 \left[\frac{PW^2}{S}\right]^{1.570}$ for fluid volumes greater than 425 ml.

### 4.2.2 Measurement Error

The standard deviation of $(PW^2/S)$ was calculated for each calibration data point and plotted in Figure 4. This repeatability error represents the minimum which can be expected for the BMS.

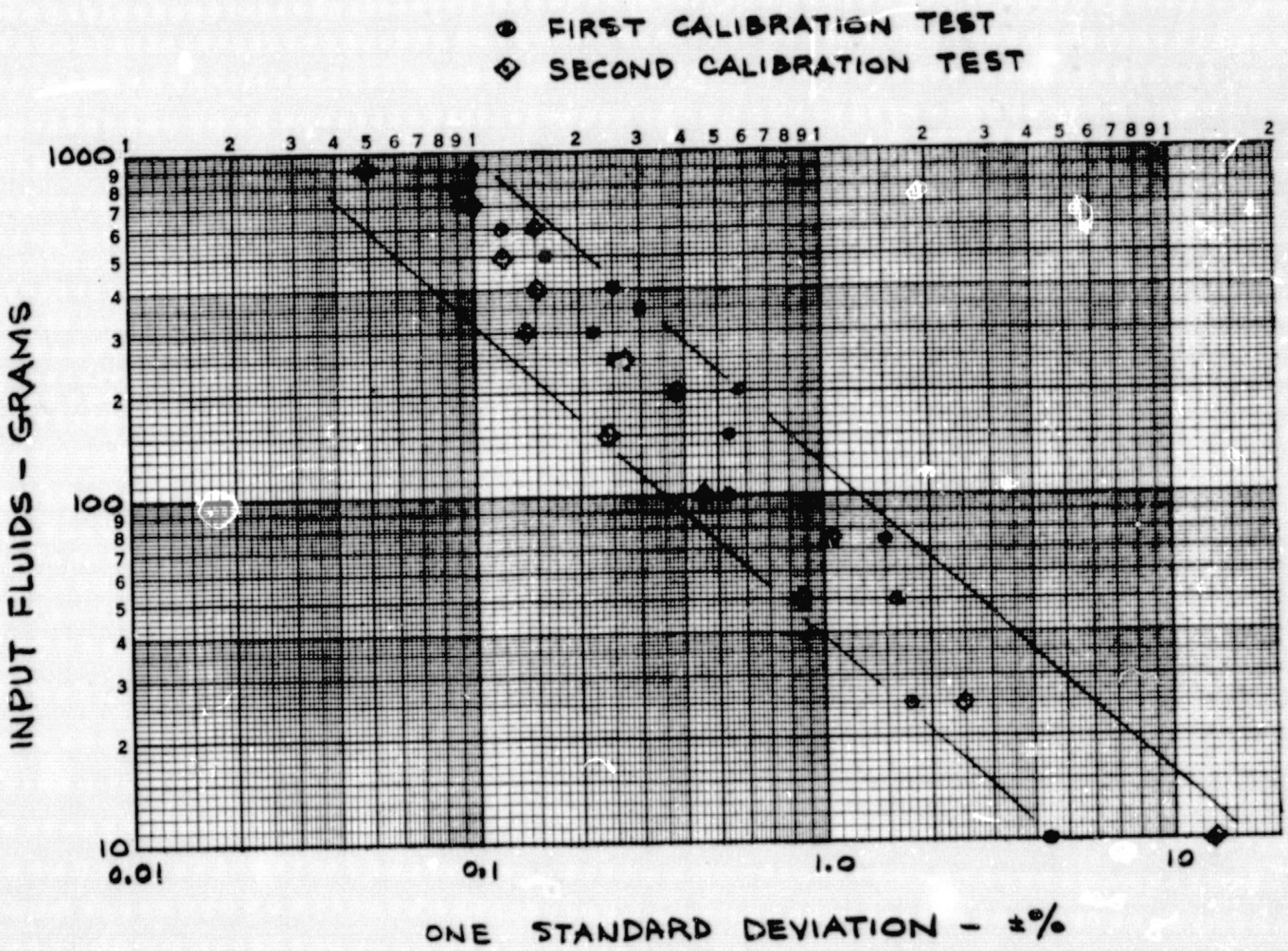



FIGURE 4 REPEATABILITY ERROR

If the approximate fluid volume equations noted in section 4.2.1 are used, an addition error due to non-linearity (over each equation volume range) must be added to the repeatability error. Tables ~ and 6 show the magnitude of this linearity error. Table 7 shows the range of the combined error. If a smaller measurement error is desired, additional data points must be obtained and a calibration curve (rather than approximation equations) used, or additional fluid volume equations derived.

4.2.3 Fluid Temperature

The previously discussed calibration tests were made using ambient temperature (70 to 75°F) water as the fluid. Approximately 100°F water was also used to verify the pressure sensor temperature compensation feature. The latter appears to be operating as planned, see Table 8.

4.2.4 Urine Samples

Table 9 shows measurement results using urine samples. Comparing with Table 7, the measurement error appears to be somewhat larger than predicted by the calibration data. However, if Table 7 is based on a $\pm 3$ sigma repeatability error, then the data of Table 9 is reasonably consistant with the calibration data.

4.2.5 Effect of Flush Cycle

Several test runs were made with the flush water tank disconnected to assess the effect of the flush cycle on the calibration. Using 400 ml ambient temperature water samples, $PW^2/S$ averaged 23.103 as compared to 23.491 with the flush tank operative (or about an 8 ml difference).

Table 5 Linearity Error, First Calibration Test

| Input | Calculated Volume[1] | Linearity Error | |
|---|---|---|---|
| 10 grams | 10.00 ml | 0.00 ml | 0.00 % |
| 25 | 24.61 | -0.39 | -1.56 |
| 50 | 50.00 | 0.00 | 0.00 |
| 75 | 76.75 | 1.75 | 2.33 |
| 100 | 101.67 | 1.67 | 1.67 |
| 150 | 150.01 | 0.01 | 0.00 |
| 200 | 198.23 | -1.77 | -0.89 |
| 250 | 249.73 | -0.27 | -0.11 |
| 300 | 302.02 | 2.02 | 0.67 |
| 350 | 351.71 | 1.71 | 0.49 |
| 400 | 399.95 | -0.05 | -0.01 |
| 500 | 502.00 | 2.00 | 0.40 |
| 600 | 597.94 | -2.06 | 0.34 |
| 700 | 700.37 | 0.37 | 0.05 |
| 800 | 800.51 | 0.51 | 0.06 |
| 900 | 900.11 | 0.11 | 0.01 |

[1]Using Table 2 equations

Table 6 Linearity Error, Second Calibration Test

| Input | Calculated Volume[1] | Linearity Error | |
|---|---|---|---|
| 10 grams | 10.00 ml | 0.00 ml | 0.00 % |
| 25 | 26.10 | 1.10 | 4.40 |
| 50 | 50.01 | 0.01 | 0.02 |
| 75 | 73.99 | -1.01 | -1.35 |
| 100 | 99.96 | -0.04 | -0.04 |
| 150 | 151.71 | 1.71 | 1.14 |
| 200 | 201.34 | 1.34 | 0.67 |
| 250 | 251.05 | 1.05 | 0.42 |
| 300 | 302.57 | 2.59 | 0.86 |
| 400 | 400.06 | 0.06 | 0.01 |
| 500 | 500.10 | 0.10 | 0.02 |
| 600 | 598.94 | -1.06 | -0.18 |
| 700 | 697.89 | -2.11 | -0.30 |
| 800 | 799.53 | -0.47 | -0.06 |
| 900 | 900.11 | 0.11 | 0.01 |

[1]Using Table 3 equations

Table 7 Combined Error Range[1]

| Input | Linearity Error[3] | Repeatability Error[2] (2 sigma) | Combined Error (range) |
|---|---|---|---|
| 10 grams | 0.00 % | ± 26.24 % | +26.24 to -26.24 % |
| 25 | 4.40 | ± 4.98 | + 9.38 to - .58 |
| 50 | 0.02 | ± 1.70 | + 1.72 to - 1.68 |
| 75 | -1.35 | ± 2.08 | + 0.73 to - 3.43 |
| 100 | -0.04 | ± 0.90 | + 0.86 to - 0.94 |
| 150 | 1.14 | ± 0.48 | + 1.62 to + 0.66 |
| 200 | 0.67 | ± 0.76 | + 1.43 to - 0.09 |
| 250 | 0.42 | ± 0.54 | + 0.96 to - 0.12 |
| 300 | 0.86 | ± 0.28 | + 1.14 to + 0.58 |
| 400 | 0.01 | ± 0.30 | + 0.31 to - 0.29 |
| 500 | 0.02 | ± 0.24 | + 0.26 to - 0.22 |
| 600 | -0.18 | ± 0.30 | + 0.12 to - o.48 |
| 700 | -0.30 | ± 0.20 | - 0.10 to - 0.50 |
| 800 | -0.06 | ± 0.18 | + 0.12 to - 0.24 |
| 900 | 0.01 | ± 0.10 | + 0.11 to - 0.09 |

[1]Second Calibration Test Data

[2]Standard Deviation From Mean, ±2 Sigma Level

[3]Using Table 3 Equations

Table 8 Warm Water Samples

| Input Sample | | | |
|---|---|---|---|
| Quantity | Temperature | $\frac{(PW^2)}{S}$ | Calculated Volume[1] |
| 200 grams | 100 °F | 13.390 | 200.16 ml |
| 200 | 101 | 13.392 | 200.19 |
| 400 | 100 | 23.411 | 398.40 |
| 400 | 100 | 23.441 | 399.01 |
| 600 | 101 | 30.629 | 598.36 |
| 600 | 103 | 30.742 | 601.83 |

[1]Using Table 3 Equations

Table 9 Urine Samples

| Input Sample Quantity | Input Sample Temperature | $(\frac{PW^2}{S})$[1] | Calculated Weight[2] | Error |
|---|---|---|---|---|
| 231. grams | 98 °F | 14.992 | 230.1 grams | -.04% |
| 217. | 75 | 14.415 | 219.2 | 1.01 |
| 172.5 | 75 | 11.949 | 174.0 | 0.87 |
| 95.5 | 75 | 7.227 | 95.0 | -0.52 |
| 45. | 98 | 3.058 | 43.8 | -2.67 |
| 23. | 75 | 1.338 | 25.0 | 8.69 |
| 20. | 75 | 1.159 | 22.7 | 13.50 |
| 200. | 40[3] | 13.541 | 202.9 | 1.45 |
| 200. | 60 (est.) | 13.491 | 202.0 | 1.00 |
| 97.5 | 98 | 7.442 | 97.8 | 0.31 |
| 82 | 75 | 5.965 | 78.9 | -3.78 |
| 70.5 | 75 | 5.122 | 68.1 | -3.40 |
| 65.5 | 75 | 4.810 | 64.1 | -2.14 |
| 47. | 75 | 3.455 | 47.6 | 1.28 |

[1]S=1.0

[2]Using Table 3 Equations And S=1.0 For Calculated Weight Comparison

[3]Refrigerated Sample

### 4.2.6 Test Procedure Error

The data noted in preceding sections also includes a procedural error, i.e., the difference between the input sample weight recorded and the actual weight of the sample. This error is estimated to be less than ±0.5 grams.

### 4.2.7 Maximum Volume

With the pressure sensor zero offset and gain adjusted as for the second calibration test, the maximum measureable volume is about 970 ml. Since fluid pressures were somewhat higher than anticipated, further adjustment (to achieve 1000 ml measurements) was outside the pressure sensor gain adjust range. Thus, for all input volumes exceeding about 970 ml, the TLM pressure equivalent output P will be constant at 4096.

### 4.2.8 Vortex Uniformity

During fluid input, the fluid vortex in the phase separator is increasing in depth. Depending on the rate of fluid input, uniformity of vortex depth is lagging the fluid input. To assure vortex uniformity, a 10 to 15 second delay after completion of fluid input and actuation of PURG or DUMP switches was used in obtaining the data noted above (and is recommended for operational use).

## 4.3 Sampling

### 4.3.1 General

Both water and urine samples were obtained using the PURG/SAMP sequence. The total sample volume was easily controlled via the SAMP switch. After a few trials, fluid leakage thru the septum was observed. This leakage may have been caused by a small burr on the tip of the sample container "needle".

The septum was replaced and the needles deburred; no further leakage occured. As a byproduct problem, fluid leakage thru the septum activates the sample container ID sensors. This causes the system to believe that a sample container is in place and thus inhibits other system operations. This condition is evident by the flashing COLL switch indicator light and by the sampling assembly illummation light ON condition. The system can be returned to normal by removing the fluid film from the ID sensors.

### 4.3.2 Overfill Protection

Several sample containers were completely filled (and thus subjected to full urine pump pressure) without leakage. However, internal venting of this pressure on removal of the sample container did not occur, resulting in external fluid release in the sampling assembly cavity (and activation of the ID sensors as noted in 4.3.1 above). This problem was eliminated by adding a second hole in the sample container needle. This second hole was located 0.100 inches further towards the needle tip from the first hole. Thus, after inadvertant overfilling (pressurizing) of the sample container, withdrawing the sample container about 0.100 inches and holding in this position for 5 to 10 seconds permits the sample container to vent internally (as originally planned). The sample container may then be removed. Note that for small fluid volume inputs to the system, a mixture of fluid and air will be pumped into the sample container. To offset any residual compression of this air, the above withdrawal procedure should be used.

### 4.3.3 Cross - Contamination

No rigorous evaluation of cross - contamination was attemped. Instead, first cut evaluation was made by adding a 87 ml fresh urine fluid input followed by the dump and flush cycles. A second 50 ml fresh water fluid input was then added.

Next, a 10 ml sample was obtained (via a sample container) and visually compared with the fresh water input. No difference in color was observed. A second test using 54 ml of urine and followed by a 50 ml fresh water input gave the same result.

The phase separator residual was found to be about 12 ml. This volume was determined by removing the phase separator inlet side housing (immediately following the last flush cycle) and pouring out the residual fluid.

The residual consists of flush water and carryover from the previous fluid input. The worse case is a very large previous urine input so that the carryover is essentially urine, i.e., flush water from previous cycle has negligible effect on residual composition. Under this condition (large urine input), and based on a 12 ml residual and two 59 ml flush water cycles, 0.343 ml of urine will remain in the residual, (compared to the 0.5 maximum specified). For a relatively small (100 ml) urine input, 0.272 ml will be retained in the residual for mixing with next fluid input. For the above worse case condition, Figure 5 shows the percentage of urine in the next fluid input carried over from the previous input.

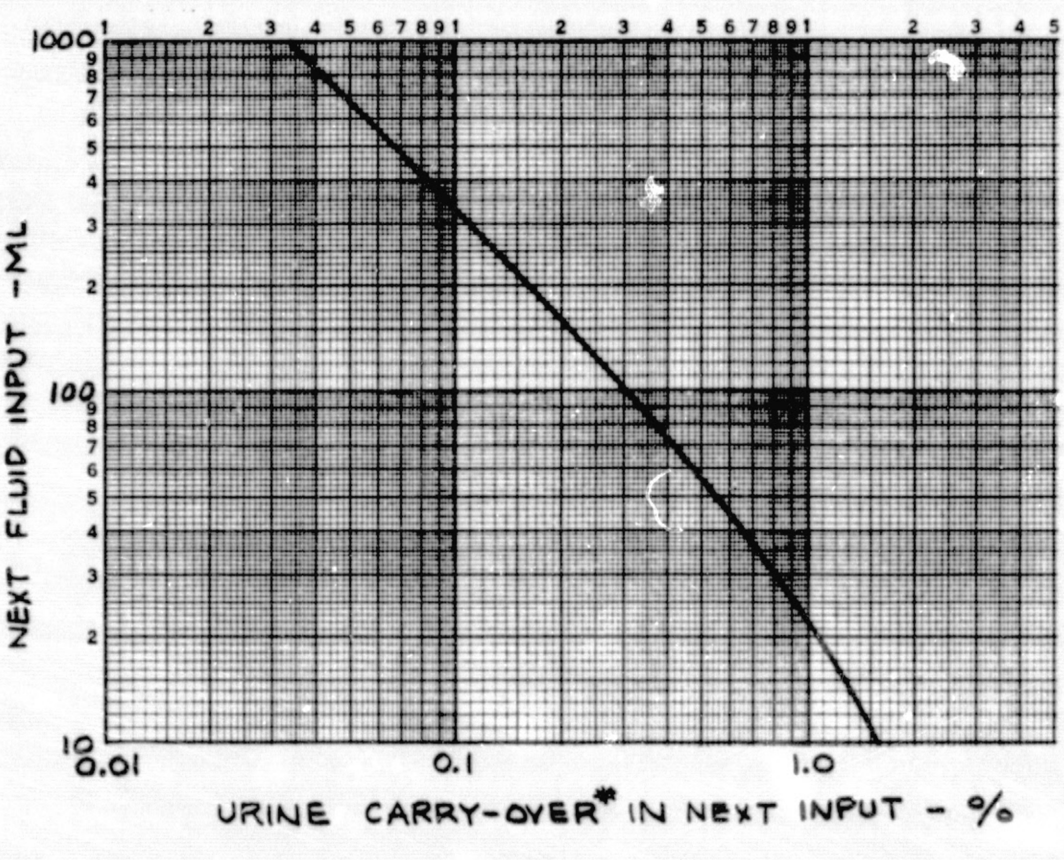
If a lower cross-contamination level is desired, a second flush can be initiated before the next system use.

#### 4.3.4 Septum Life

Separate septum life tests were accomplished (see PIR 1R60-75-159 for details). Test results indicate a septum life in excess of 500 sample container insertion/withdrawal cycles.

#### 4.3.5 Storage

A prototype sample container was filled with urine and stored at 0°F. The subsequent freezing action did not damage or expand the sample container.




* WORSE CASE CONDITION

FIGURE 5 CROSS-CONTAMINATION

### 4.3.6 Purge Volume

Purge volume was determined indirectly by noted the pressure sensor output voltage (via the test connector) just before and after actuation of the PURG switch. These values were then related to fluid volume using Figure 2. The purge volume was consistant at 14 ml for the fluid inputs checked (150,200 and 700 ml).

## 4.4 Mechanical/Electrical

### 4.4.1 Mechanical

#### 4.4.1.1 Operating Time

Figure 6 shows system operating time from start of the dump cycle to automatic shut-off. Note that the time from start DUMP to TLM out includes a 25.6 sec delay triggered when the pressure sensor output drops to about 0.7 volts (equivalent to about 40 ml remaining in the phase separator).

The apparent higher pump-out rate for an increase in input volume may be due to two factors. As the input volume increases, the input pressure to the urine pump increases thus increasing the flow rate. When the fluid volume remaining in the phase separator drops to below about 75 ml, some air starts to be pumped along with the fluid, the proportion of air increasing as pump-out continues. Thus the fluid flow rate drops and a proportionate longer time is required before the 40 ml trigger (cut-off) level is reached.

#### 4.4.1.2 Urine Pump Rate

Figure 7 shows the average urine pump flow rate required to reduce the initial input volume down to the 40 ml cut-off level.

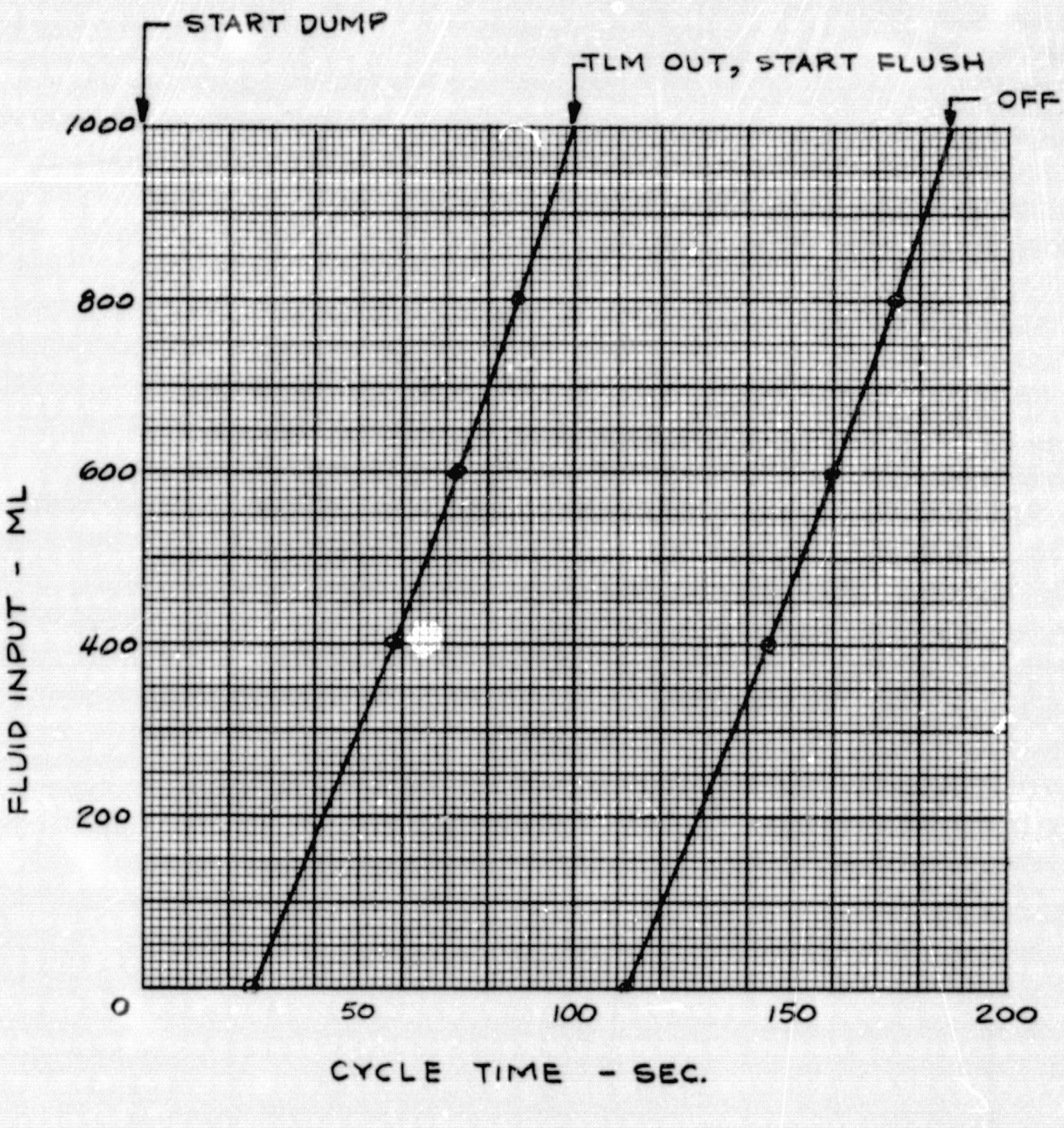



FIGURE 6 CYCLE TIME

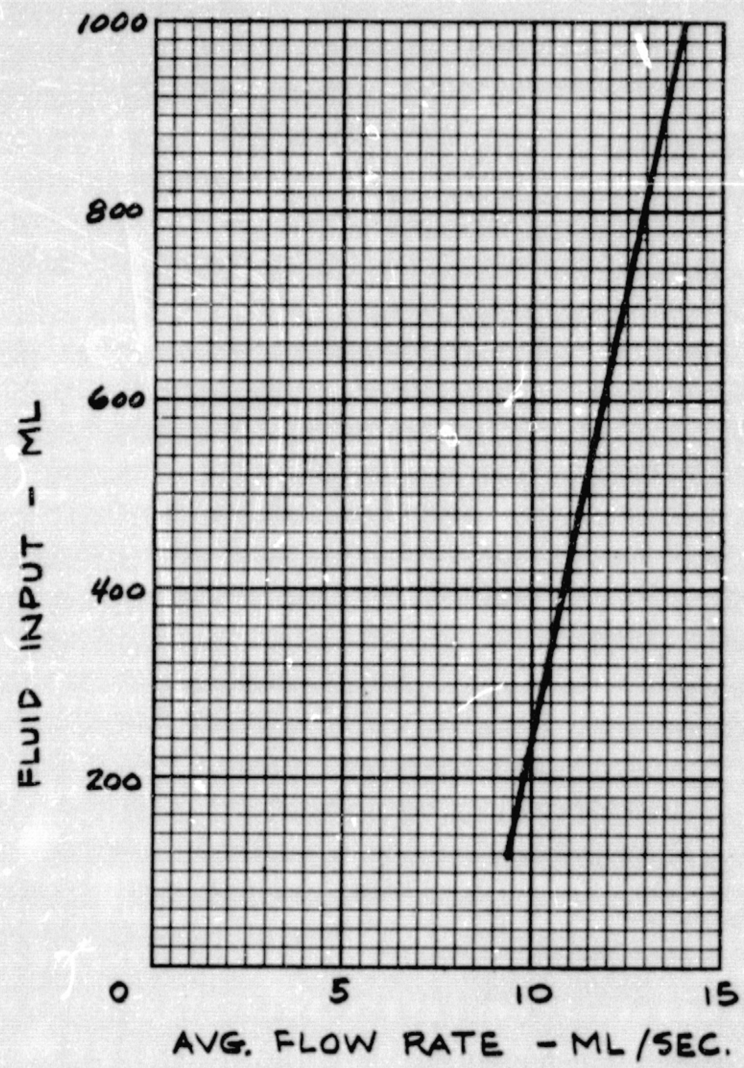



FIGURE 7 URINE PUMP FLOW RATE

4.4.1.3 Flush Water Use

With the urinal hose disconnected from the phase separator, the flush water input was collected and weighted. The amount per flush averaged 59 ml. Assuming an effective portable flush water reservoir capacity of 5.0 liters (total volume minus 5%), 42 BMS use cycles are possible before refilling the portable reservoir.

4.4.1.4 Transport Airflow

The pressure drop due to the transport air flow was measured in two separate tests: one for the urinal hose and urinal; the other for the BMS hardware without the urinal or outlet hoses connected. Test results are shown in Figure 8. Curve A shows the pressure drop at various flow rates for the urinal hose only. Curve B shows the results for the BMS without the urinal or outlet hose. The two curves are added to show the total pressure drop through the system.

The plots do not show the contribution of the outlet hose. The ID of this hose is larger than that of the urinal hose and the length has been arbitrarily selected (as it will depend on the relative position of the BMS and the WCS). In its present configuration, this hose contributes a pressure drop of 1/2 inch W. G. Max. at 8 CFM.

4.4.1.5 Component Operating Temperatures

During the calibration tests, the BMS (with aft cover removed for access to the test connector) was operated almost continuously over periods ranging up to about three hours duration. At no time did the surface of such active elements as the motors or electronic box feel more than slightly warm to the touch.

4.4.2 Electrical

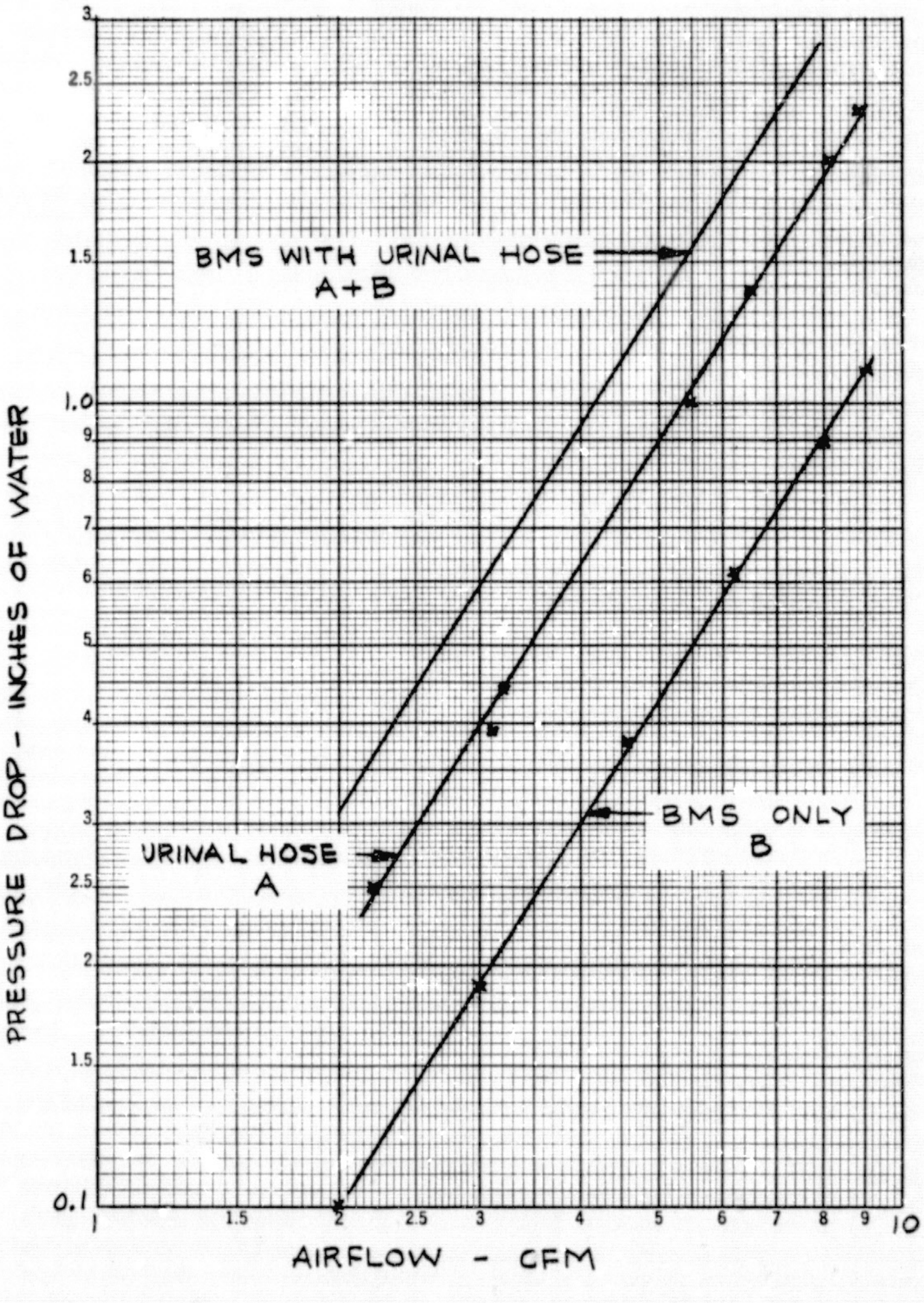



FIGURE 8 AIRFLOW/PRESSURE DROP

4.4.2.1 Shock Hazard

The resistance between the ground strap terminal and the phase separator motor was determined to be less than 0.01 ohm (lower reading limited by sensitivity of meter). Similar results were obtained for the ground strap terminal and bezel combination.

4.4.2.2 Limit Voltage Operation

A DC Input range of 24 to 32 volts did not appear to influence the operation of the BMS.

4.4.2.3 Input Power

Table 10 shows the phase separator motor power characteristics; Table 11 shows the phase separator motor power as a function of input fluid volume. Based c these two tables, phase separator input power will range from about 24 to 34 watts.

BMS peak input power occurs at actuation of either the PURGE, SAMP or DUMP switches. At this instant, the urine pump, phase separator, solenoid value and electronics are all operating. Thus peak power required for the BMS is as shown in Table 12.

4.5 Misc. Observations/Data

4.5.1 Airflow Sensor

The airflow sensor set point must accommodate the increased air temperature due to 100°F fluid inputs. Thus the set point, if based on cooler ambient temperature airflow, may be too low. This will cause the airflow sensor to erroneously indicate a low airflow condition for 100°F fluid inputs.

4.5.2 Number of Tests

Between 400 and 500 COLL/DUMP sequences were successfully completed to obtain the test data noted in this report.

Table 10 Phase Separator Power[1]

| Motor Speed | Motor Power | |
|---|---|---|
| | Input | Output |
| 398.1 rpm | 20 watts | 0 watts |
| 394.8 | 28 | 8 |
| 391.4 | 38 | 17 |
| 388.1 | 47 | 25 |
| 381.4 | 56 | 34 |
| 368.0 | 67 | 40 |

[1]As Supplied by Motor Vendor

Table 11 Phase Separator Operating Speed

| Input Volume[1] | Operating Speed Range[2] |
|---|---|
| 0 ml | 395.6 to 396.4 rpm |
| 50 | 393.9 to 394.3 |
| 100 | 393.7 to 394.3 |
| 200 | 393.3 to 393.9 |
| 300 | 393.2 to 393.6 |
| 400 | 393.0 to 393.3 |
| 500 | 393.2 to 394.1 |
| 600 | 392.8 to 394.1 |
| 700 | 392.7 to 394.6 |
| 800 | 392.6 to 393.0 |
| 900 | 392.7 to 393.1 |

[1]Ambient Temperature Water

[2]Data From Second Calibration Test; Input Voltage Frequency Constant at 398/399 Hz

Table 12 Estimated BMS Peak Power

| Component | Est. Power Required 400 Hz | Est. Power Required DC |
|---|---|---|
| Phase Separator | 34 watts | -- |
| Urine Pump | 25 | -- |
| Solenoid Value | -- | 7 watts |
| Electronics | -- | 1 |
| | 59 watts | 8 watts |

6.5 GSE Supplemental Information

GE sketch 56236-680, "Interconnect Wiring Diagram", BMS GSE.

PIR 1R60-75-160, "Ground Station Receiver Design".

Recorder, Model DPP-7, Datel Systems, Inc.

B SK 56236-68C

REVISIONS

| ZONE | LTR | DESCRIPTION | DATE | APPROVED |
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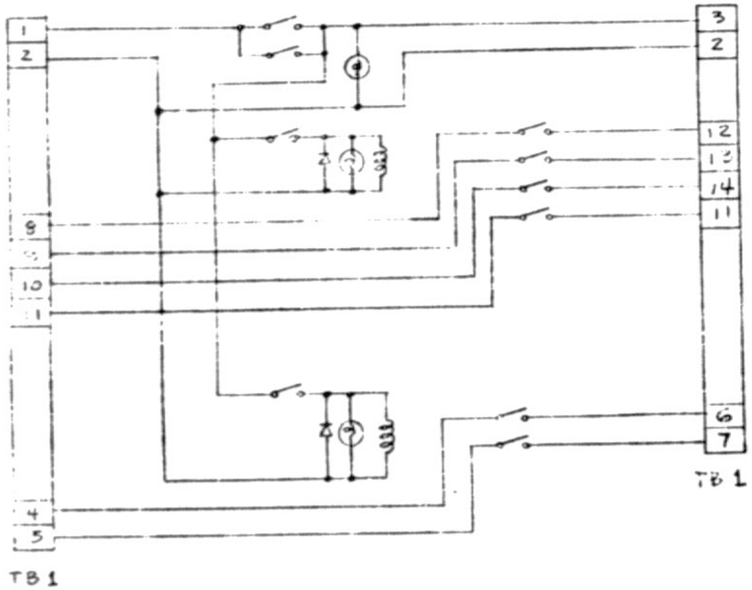
| | | | | |




TB 1

1 +28 VDC IN
2 DC RTN } TO BMS AND BLOWER
3 +28 VDC OUT
4 115 V, 60 HZ IN
5 115 V, 60 HZ IN
6 115 V, 60 HZ OUT } TO PRINTER AND PWR. SUPPLY
7 115 V, 60 HZ OUT
8 200 V, 400 HZ, Ø1 IN
9 200 V, 400 HZ, Ø2 IN
10 200 V, 400 HZ, Ø3 IN
11 400 HZ COM
12 200 V, 400 HZ OUT TO BMS
13 200 V, 400 HZ OUT TO BMS
14 200 V, 400 HZ OUT TO BMS

TB 2

1 +5 V DC (WH)
2 RET (BLK)
3 RET (BLK)
4 +15 V DC (R)
5 −15 V DC (WH)
6 TLM FROM BMS
7 TLM FROM BMS
8 TLM GRD
9 BLOWER
10 BLOWER

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:
FRACTIONS ± DECIMALS ± ANGLES ±
ALL SURFACES ✓
MATL

SIGNATURES: DRAWN / CHECKED / ISSUED / ENGRG / MFG / MATLS

GRD. STATION

GENERAL ELECTRIC
DEPT LOC

INTERCONNECT WIRING DIAGRAM

SIZE B | CODE IDENT NO BMS | SK 56236-68C

SCALE | SHEET

GENERAL ELECTRIC
SPACE DIVISION
PHILADELPHIA

# PROGRAM INFORMATION REQUEST / RELEASE

| PIR NO. | *CLASS. LTR. | OPERATION | PROGRAM | SEQUENCE NO. | REV. LTR. |
|---|---|---|---|---|---|
| | U | 1R60 | 75 | 160 | |

*USE "C" FOR CLASSIFIED AND "U" FOR UNCLASSIFIED

| FROM | TO |
|---|---|
| V. P. Long, Jr.<br>Room U-2432, VFSC, Ext. 1469 | G. L. Fogal<br>Room U-1240, VFSC, Ext. 5636 |

| DATE SENT | DATE INFO. REQUIRED | PROJECT AND REQ. NO. | REFERENCE DIR. NO. |
|---|---|---|---|
| 8/7/75 | | | |

SUBJECT

GROUND STATION RECEIVER DESIGN

INFORMATION REQUESTED/RELEASED

The ground station receiver accepts the serial data transmitted by the BMS decodes, stores, and converts it to a printed format.

Referring to schematic 1, the incoming Manchester II biphase data is converted to TTL level by A3 and its associated circuits. It should be noted that the input is transformer-coupled into A3. A18 and A7 form a transition detector resetting A15. A15 is a counter used to extract a 2 MHz clock from the data. A16 is a 16 MHz crystal oscillator which drives A15. The generated 2 MHz clock is used to sample the incoming data stream A5, A6, and A8 forming a detector for the illegal Manchester II bit characterizing sync. Upon its detection, a 1 MHz clock is formed which is used to clock the remaining 16 bits of data (17 bits minus parity) into the data storage register consisting of A20, A30, A29, A28, A27 and A26. This process is repeated for the remaining two words in a transmission.

Referring to schematic 2, A37 is a timer which activates the print cycle approximately one millisecond after detection of the first sync. A9, A10, A11, A14, A24 and A25 perform the logic necessary to control selector switches A38, A39, A40, A48, A49, A50 and A45 which select the data to be printed on each line. A53 through A60 perform a binary-to-binary-coded-decimal conversion upon the received data. The resultant outputs are presented to the printer.

A35 provides the necessary pulse width for the PRINT command. The pulse width is not critical, the one millisecond value being in the middle of the acceptable range (1 microsecond to 300 microseconds). The PRINT command is delayed by A34 to allow time for the data to settle after being switched at the end of the preceding line.

Figures 6 and 7 are timing diagrams for the above processes. Figures 3, 4 and 5 contain wiring details.

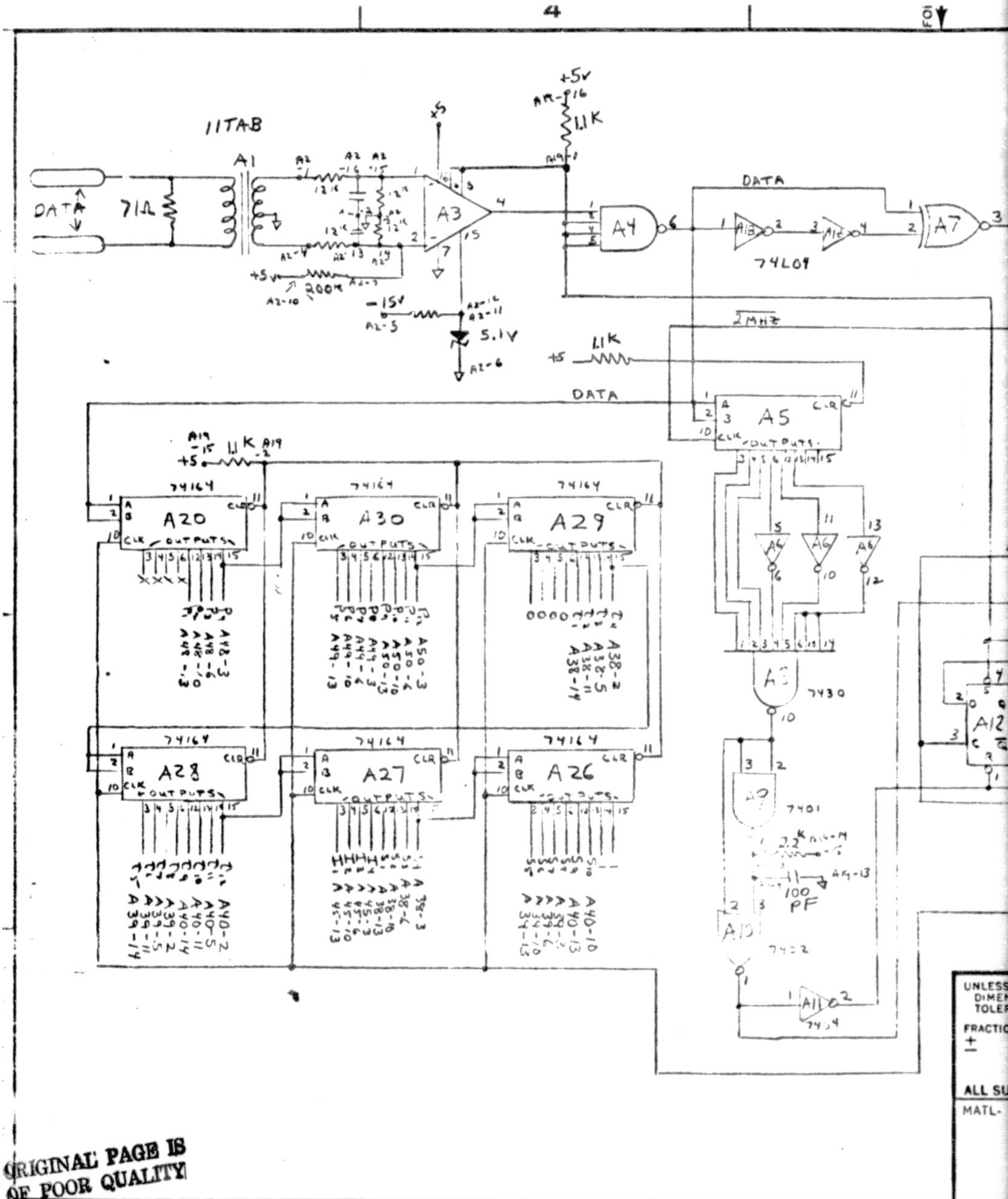
G. Fogal (3)
File

PAGE NO. 1 OF 1

RETENTION REQUIREMENTS

| COPIES FOR | MASTERS FOR |
|---|---|
| 1 MO. | 3 MOS. |
| 3 MOS. | 6 MOS. |
| 6 MOS. | 12 MOS. |
| MOS. | MOS. |
| | DONT DESTROY |

FORM 1020 B REV. (9-70)



4
FOLD
11TAB
A1
DATA
71Ω
+5V
1.1K
A3
A4
A13
A16
A7
74L09
DATA
1MHZ
+5
1.1K
-15V
5.1V
200K
DATA
A5
CLR
CLK
OUTPUTS
A6
A8
7430
A12
A9
7401
2.2K
100 PF
A10
7402
A11
7404
74164
A20
74164
A30
74164
A29
74164
A28
74164
A27
74164
A26
UNLESS
DIMEN
TOLERA
FRACTIO
ALL SU
MATL-
5
4
FOLD

3 | 2 | B

## REVISIONS

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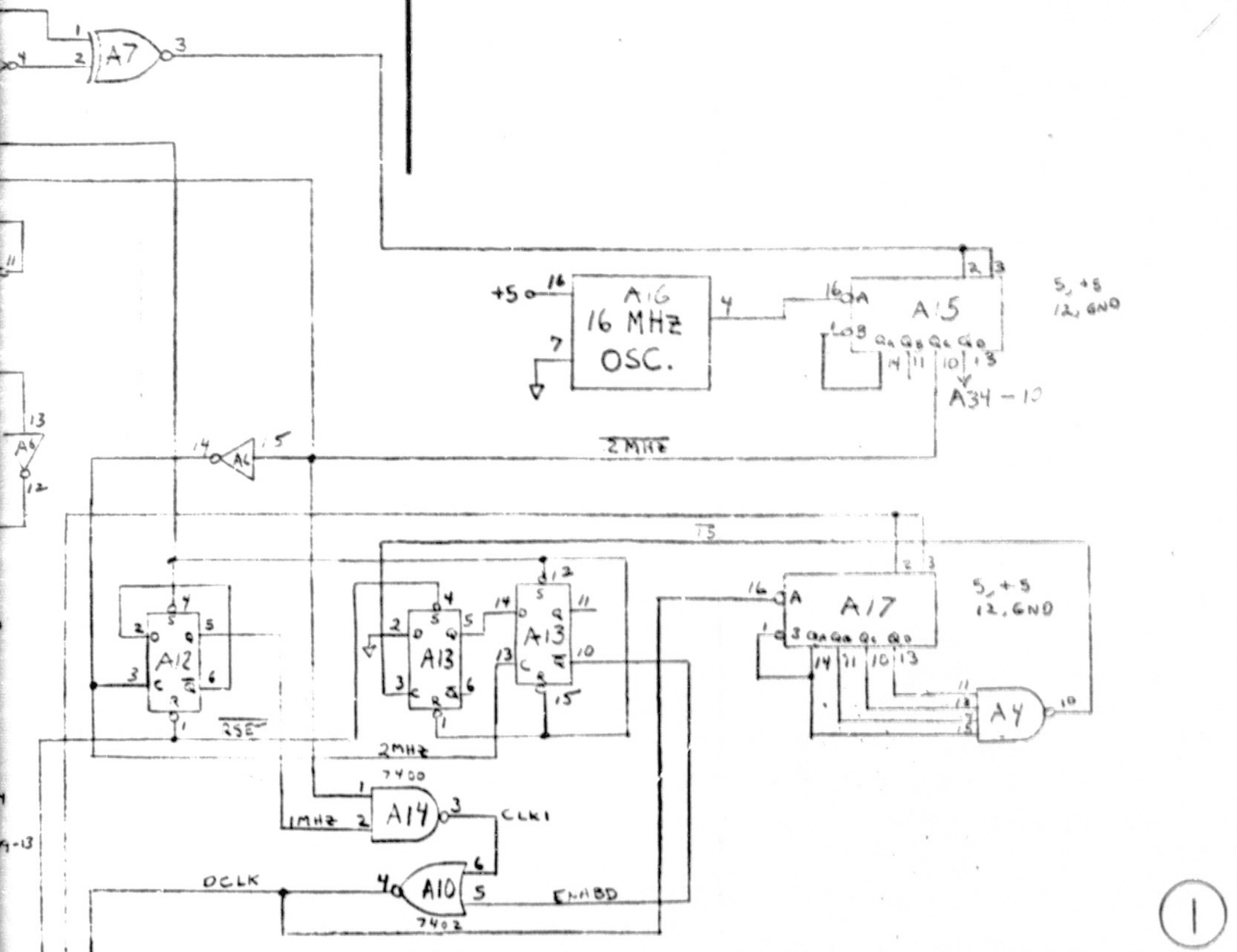



1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:
FRACTIONS ± DECIMALS ± ANGLES ±
ALL SURFACES ✓
MATL.

| SIGNATURES | DAY | MO | YR |
|---|---|---|---|
| DRAWN | | | |
| CHECKED | | | |
| ISSUED | | | |
| ENGRG | | | |
| MFG | | | |
| MATLS | | | |

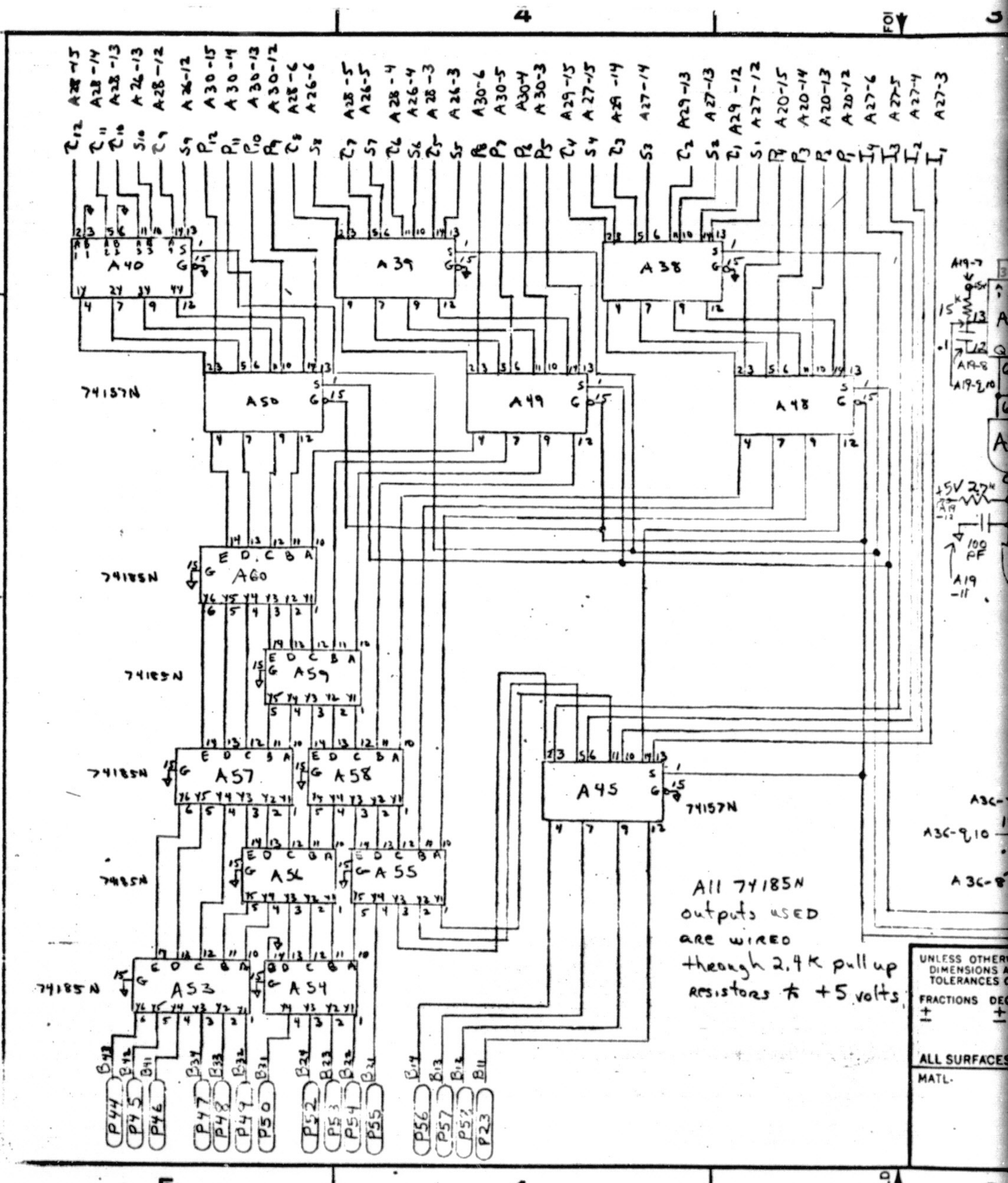
GENERAL ELECTRIC
DEPT LOC

RECEIVER

SIZE B | CODE IDENT NO. | | DIST TO
SCALE | | SHEET

3 | 2

FOLDOUT FRAME 2




FOLDOUT FRAME 1

| REVISIONS | | | | |
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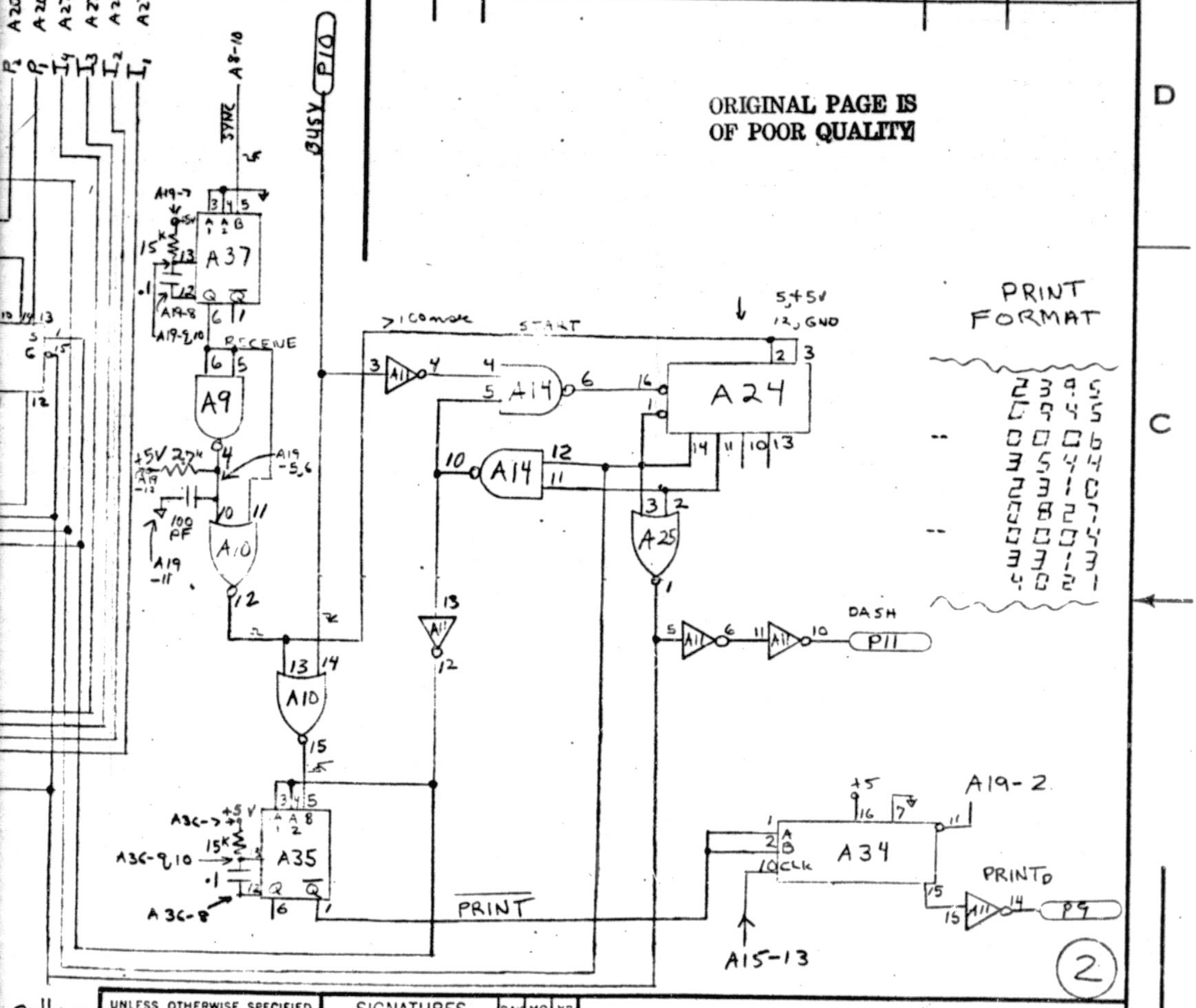


(2)

+ pull up
+5 volts

| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: | SIGNATURES | DAY | MO | YR |
|---|---|---|---|---|
| FRACTIONS ± DECIMALS ± ANGLES ± | DRAWN | | | |
| | CHECKED | | | |
| | ISSUED | | | |
| ALL SURFACES ✓ | ENGRG | | | |
| | MFG | | | |
| MATL. | MATLS | | | |

GENERAL ELECTRIC
DEPT LOC

BINARY-TO-BCD / PRINTER CONTROL

| SIZE | CODE IDENT NO. | |
|---|---|---|
| B | | |
| SCALE | | SHEET |

FOLDOUT FRAME 2

D

C

B

| FROM | TO |
|---|---|
| A60 - 6 | A47-1 |
| A60 -5 | A47 -2 |
| A60 -4 | A47 -3 |
| A60 -3 | A47 -4 |
| A60 -2 | A47 -5 |
| A60 -1 | A47 -6 |
| A59 -5 | A47 -7 |
| A59 -4 | A46 -1 |
| A59 -3 | A46 -2 |
| A59 -2 | A46 -3 |
| A59 -1 | A46 -4 |
| A58- 5 | A44-4 |
| A58 -4 | A44 -5 |
| A58 - 3 | A44 -6 |
| A58- 2 | A44 -7 |
| A58 -1 | A43 -1 |
| A57-6 | A46 -5 |
| A57 - 5 | A46 -6 |
| A57 -4 | A46 -7 |
| A57 -3 | A44 -1 |
| A57 -2 | A44 -2 |
| A57 -1 | A44 -3 |
| A56 -5 | A43 -2 |
| A56 -4 | A43 -3 |
| A56 -3 | A43 -4 |
| A56 -2 | A43 -5 |
| A56 -1 | A43 -6 |
| A55 -5 | A43 -7 |
| A55 -3 | A36 - 2 |
| A55 -2 | A36 -3 |
| A55 -1 | A36 -4 |

UNLESS OTH
DIMENSIO
TOLERA
FRACTIONS
±
ALL SURFA
MATL-

5 4

FOLD FOLD

FOLDOUT FRAME

| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | LTR | DESCRIPTION | DATE | APPROVED |
| | | | | |

NOTE: ALL "TO" ENTRIES ARE RETURNED TO +5 Volts VIA a 2.4K RESISTOR.

③

| | | |
|---|---|---|
| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ± DECIMALS ± ANGLES ± | SIGNATURES: DRAWN, CHECKED, ISSUED, ENGRG, MFG, MATLS (DAY MO YR) | GENERAL ELECTRIC DEPT LOC |
| ALL SURFACES ✓ | | RESISTOR PULLUP LOCATIONS FOR SN74185 INTEGRATED CIRCUITS |
| MATL- | | SIZE B · CODE IDENT NO. |
| | | SCALE · SHEET |

FOLDOUT FRAME 2

D

C

B

## C1

| FROM | TO |
|---|---|
| C1-A1 | C1-A3, C1-B2 |
| C1-A2 | NC |
| C1-A3 | C1-A1, C1-A4 |
| C1-A4 | C1-A3, C1-A5, C3-8 |
| C1-A5 | C1-A4, C1-A6 |
| C1-A6 | C1-A5, C1-A7 |
| C1-A7 | C1-A6 |
| C1-A8 | NC |
| C1-A9 | C4-3 |
| C1-A10 | C4-7 |
| C1-A11 | NC |
| C1-A12 | NC |
| C1-A13 | C4-2 |
| C1-A14 | C3-5 |
| C1-A15 | C3-1 |
| C1-B1 | C3-12 |
| C1-B2 | C1-A1, C1-B3 |
| C1-B3 | C1-B2, C1-B6 |
| C1-B4 | NC |
| C1-B5 | NC |
| C1-B6 | C1-B3, C1-B7 |
| C1-B7 | C1-B6, C1-B11 |
| C1-B8 | C4-1 |
| C1-B9 | C4-5 |
| C1-B10 | NC |
| C1-B11 | C1-B7 |
| C1-B12 | NC |
| C1-B13 | NC |
| C1-B14 | C3-14 |
| C1-B15 | C4-6 |

## C2

| FROM | TO |
|---|---|
| C2-A1 | NC |
| C2-A2 | NC |
| C2-A3 | NC |
| C2-A4 | NC |
| C2-A5 | NC |
| C2-A6 | NC |
| C2-A7 | NC |
| C2-A8 | NC |
| C2-A9 | NC |
| C2-A10 | NC |
| C2-A11 | NC |
| C2-A12 | NC |
| C2-A13 | C3-3 |
| C2-A14 | NC |
| C2-A15 | C3-7 |
| C2-B1 | NC |
| C2-B2 | NC |
| C2-B3 | NC |
| C2-B4 | NC |
| C2-B5 | C4-14 |
| C2-B6 | NC |
| C2-B7 | C3-4 |
| C2-B8 | NC |
| C2-B9 | NC |
| C2-B10 | C3-2 |
| C2-B11 | C3-6 |
| C2-B12 | C3-13 |
| C2-B13 | NC |
| C2-B14 | C4-4 |
| C2-B15 | C4-8 |

## C3

| FROM | TO |
|---|---|
| C3-1 (P44) | C1-A15 |
| C3-2 (P45) | C2-B10 |
| C3-3 (P46) | C2-A13 |
| C3-4 (P47) | C2-B7 |
| C3-5 (P48) | C1-A14 |
| C3-6 (P49) | C2-B11 |
| C3-7 (P50) | C2-A15 |
| C3-8 (P15) | C1-A4 |
| C3-9 (P14) | NC |
| C3-10 (P13) | NC |
| C3-11 (P12) | NC |
| C3-12 (P11) | C1-B1 |
| C3-13 (P10) | C2-B2 |
| C3-14 (P9) | C1-B14 |

UNLESS
DIMENS
TOLERA
FRACTION
±
ALL SUR
MATL-

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OF POOR QUALITY

FOLDOUT FRAME

5 4

FOLD

| ZONE | LTR | REVISIONS DESCRIPTION | DATE | APPROVED |
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| | | | | |

D

C3

| FROM | TO |
|---|---|
| -1 (P44) | C1-A15 |
| -2 (P45) | C2-B10 |
| -3 (P46) | C2-A13 |
| -4 (P47) | C2-B7 |
| -5 (P48) | C1-A14 |
| -6 (P49) | C2-B11 |
| -7 (P50) | C2-A15 |
| -8 (P15) | C1-A4 |
| -9 (P14) | NC |
| -10 (P13) | NC |
| -11 (P12) | NC |
| -12 (P11) | C1-B1 |
| -13 (P10) | C2-B2 |
| -14 (P9) | C1-314 |

C4

| FROM | TO |
|---|---|
| C4-1 (P52) | C1-B8 |
| C4-2 (P53) | C1-A13 |
| C4-3 (P54) | C1-A9 |
| C4-4 (P55) | C2-B14 |
| C4-5 (P56) | C1-B9 |
| C4-6 (P57) | C1-B15 |
| C4-7 (P58) | C1-A10 |
| C4-8 (P23) | C2-B15 |
| C4-9 (P22) | NC |
| C4-10 (P21) | NC |
| C4-11 (P2[illegible]) | NC |
| C4-12 (P[illegible]) | NC |
| C4-13 (P[illegible]) | NC |
| C4-14 (P17) | C2-B5 |

C

NOTES:

1. C1, C2 are located on the rear of the DIGITAL PANEL PRINTER

2. C3, C4 are located within the output jack field of the wire wrap board. The P-numbers refer to the output pin numbers in the jack field.

4

| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ± DECIMALS ± ANGLES ± | SIGNATURES | DAY | MO | YR | GENERAL ELECTRIC DEPT LOC |
|---|---|---|---|---|---|
| | DRAWN | | | | |
| | CHECKED | | | | |
| | ISSUED | | | | |
| | ENGRG | | | | INTERCONNECTIONS - WIRE WRAP BOARD TO PANEL PRINTER |
| ALL SURFACES ✓ | MFG | | | | |
| MATL- | MATLS | | | | SIZE B / CODE IDENT NO. |
| | | | | | SCALE / SHEET |

DIST TO

FOLD 3 2

FOLDOUT FRAME 2

## C5

| | |
|---|---|
| C5-1 (P36) | +5 VOLT |
| C5-2 (P37) | NC |
| C5-3 (P38) | -15 VOLT |
| C5-4 (P39) | NC |
| C5-5 (P40) | DATA |
| C5-6 (P41) | NC |
| C5-7 (P42) | DATA |
| C5-8 (P7) | NC |
| C5-9 (P6) | NC |
| C5-10 (P5) | NC |
| C5-11 (P4) | NC |
| C5-12 (P3) | -15 VOLT |
| C5-13 (P2) | NC |
| C5-14 (P1) | +5 VOLT |

## C6

| | |
|---|---|
| C6-1 (P64) | NC |
| C6-2 (P65) | NC |
| C6-3 (P66) | NC |
| C6-4 (P67) | NC |
| C6-5 (P68) | NC |
| C6-6 (P69) | NC |
| C6-7 (P70) | GND |
| C6-8 (P35) | GND |
| C6-9 (P34) | NC |
| C6-10 (P33) | NC |
| C6-11 (P32) | NC |
| C6-12 (P31) | NC |
| C6-13 (P30) | NC |
| C6-14 (P29) | NC |

UNLESS
DIMENS
TOLERA

FRACTION
±

ALL SUR

MATL-

| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | LTR | DESCRIPTION | DATE | APPROVED |
| | | | | |

D

C

NOTES:

1. C5, C6 are located within the output jack field of the wire wrap board. The P-numbers refer to the output pin numbers in the jack field.

5

| | | | | | |
|---|---|---|---|---|---|
| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS ± DECIMALS ± ANGLES ± | SIGNATURES | DAY | MO | YR | GENERAL ELECTRIC DEPT LOC |
| | DRAWN | | | | |
| | CHECKED | | | | INTERCONNECTIONS - WIRE WRAP BOARD TO POWER SUPPLY & DATA |
| | ISSUED | | | | |
| | ENGRG | | | | |
| ALL SURFACES ✓ | MFG | | | | |
| MATL- | MATLS | | | | SIZE B · CODE IDENT NO. |
| | | | | | SCALE · SHEET |

DIST TO

FOLD 3 · 2

FOLDOUT FRAME 2

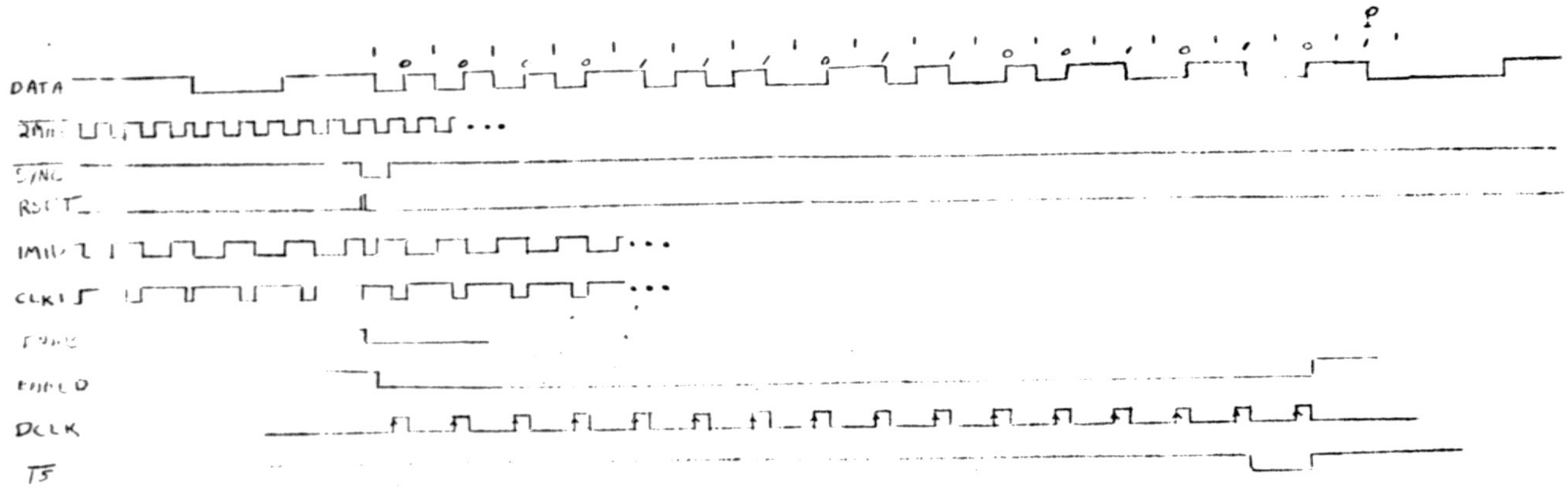



FIGURE 6 RECEIVE TIMING

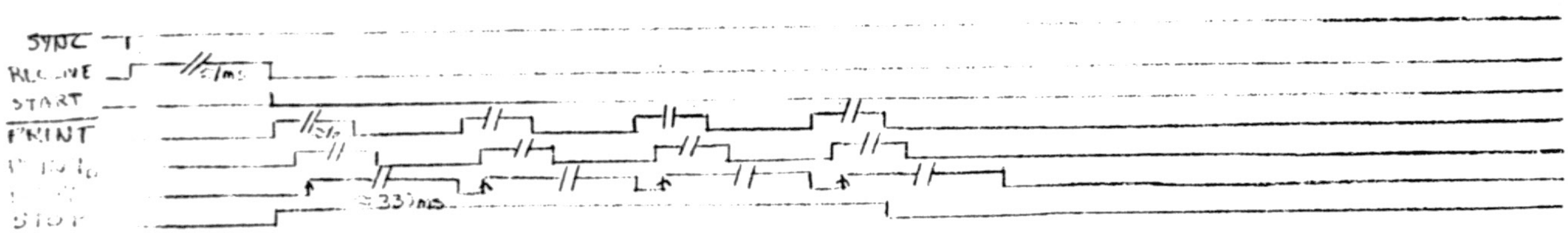
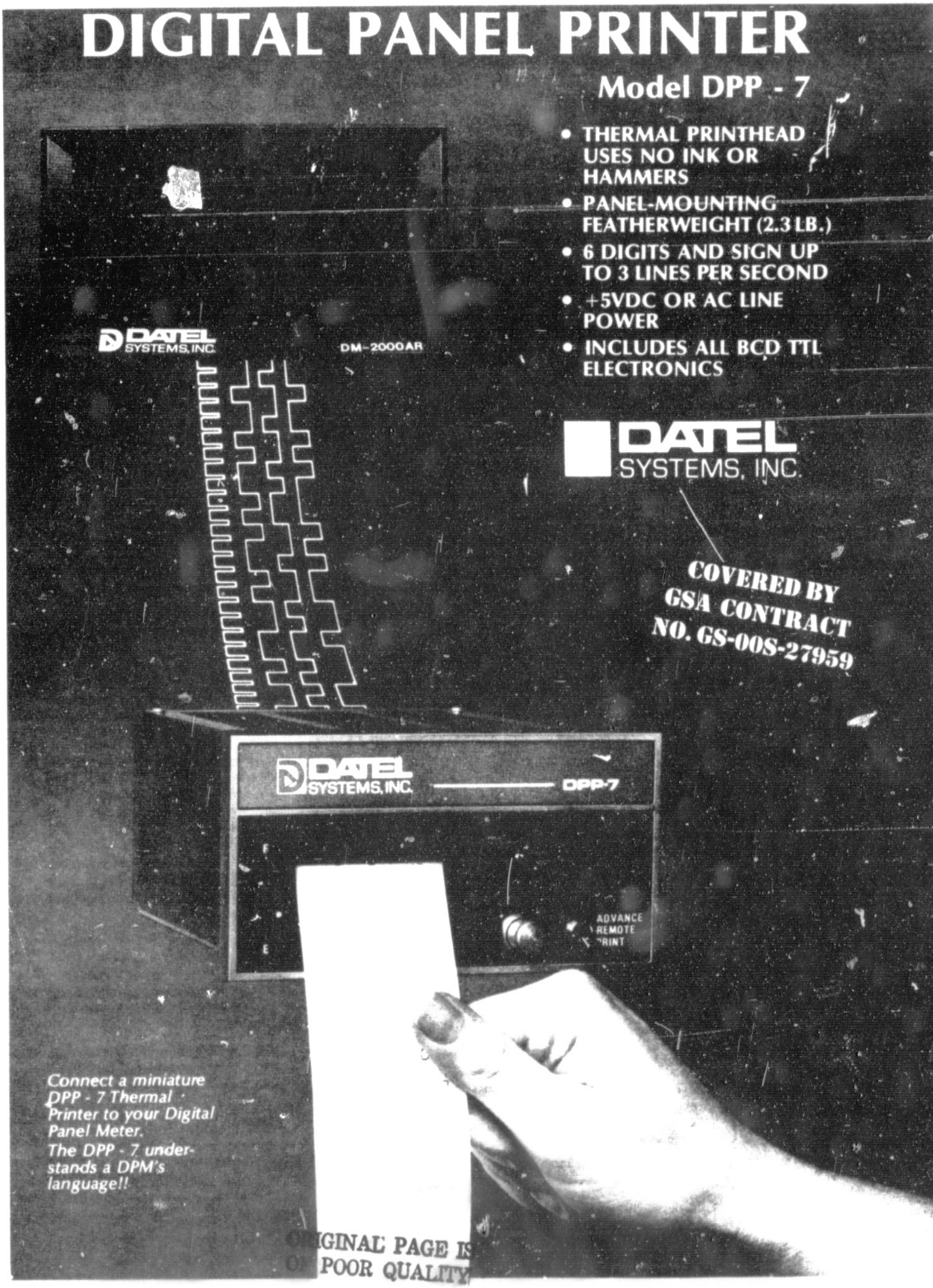
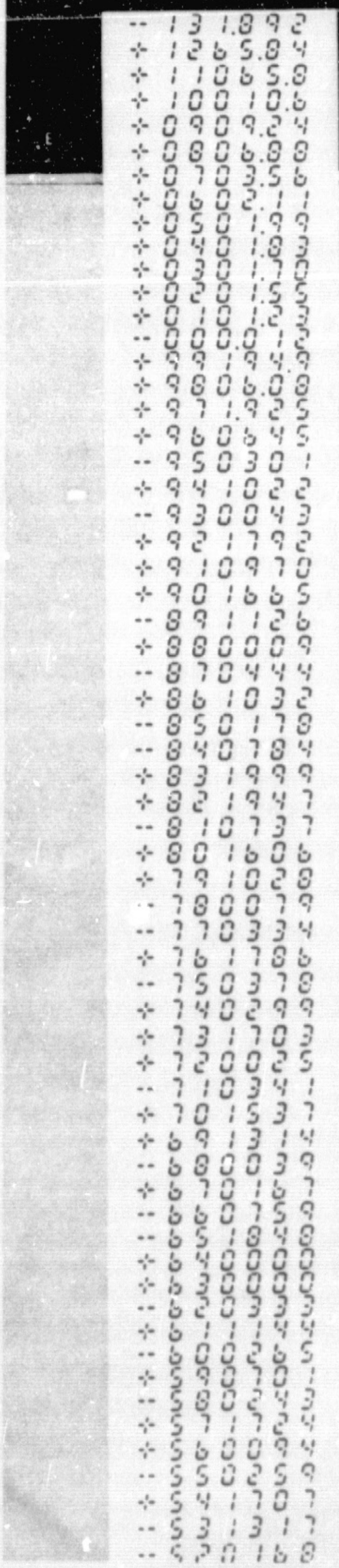



FIGURE 7 PRINT TIMING


DIGITAL PANEL PRINTER
Model DPP - 7
• THERMAL PRINTHEAD USES NO INK OR HAMMERS
• PANEL-MOUNTING FEATHERWEIGHT (2.3 LB.)
• 6 DIGITS AND SIGN UP TO 3 LINES PER SECOND
• +5VDC OR AC LINE POWER
• INCLUDES ALL BCD TTL ELECTRONICS
DATEL SYSTEMS, INC.
COVERED BY GSA CONTRACT NO. GS-00S-27959
DATEL SYSTEMS, INC.
DM-2000AR
DATEL SYSTEMS, INC.
DPP-7
ADVANCE
REMOTE
PRINT
Connect a miniature DPP - 7 Thermal Printer to your Digital Panel Meter.
The DPP - 7 understands a DPM's language!!

# DPP-7 DIGITAL PANEL PRINTER

## FEATURES

- 3 Lines/Second OEM-Reliable Thermal Printer
- Includes All Electronics for BCD Inputs
- 6 Numeric Columns and Sign
- Selectable Leading Zero Blanking
- Positive or Negative True TTL/DTL Inputs
- +5VDC Power (2.3 lbs.) or AC (4.2 lbs.)
- $475.00 Single Quantity
- Last Line Visible Immediately After Printing

## DESCRIPTION

Imagine a low cost 7-column panel-mounting printer just slightly larger than most digital panel meters. Imagine this lightweight, high-reliability digital panel printer installed in your instrument or system front panel. And imagine an inkless, non-impact thermal printing method with only two moving parts which will last for years.

This is Datel's miniature 3 line per second DPP-7 thermal panel printer. A no-nonsense, simple to apply, OEM-designed digital output device that weighs in at only 2.3 pounds (1,1Kg). OEM features are designed in to the DPP-7 such as selectable leading zero blanking, selectable positive or negative true coding inputs and choice of +5VDC or AC line power. Full parallel TTL input BCD electronics are included as standard.

Other OEM design features include a selection of printout formats, manual print and advance front panel switch, and a low-paper switch output. A unique mounting technique uses an aluminum housing which attaches directly through a front panel cutout. This housing permanently holds the electronics, although the mechancial assembly can be completely removed for paper replacement using a single front panel thumbscrew. As the mechanical assembly is removed, it disconnects from the internal electronics PC board connectors, so that no lethal power voltages are exposed during paper reloading. However, the external PC board connectors at the rear of the case remain connected to the internal electronics.

The housing supports the weight of the mechanical assembly and is mounted on a front panel through a 4.50" x 2.72" cutout and secured by four screws. Three DPP-7 panel printers can conveniently be mounted across a 19" x 3-1/2" high rack mount panel.

OEM pricing makes the DPP-7 ideal for instrument products. Comparable impact parallel printers with BCD decoding and drive electronics usually list for more than the DPP-7.

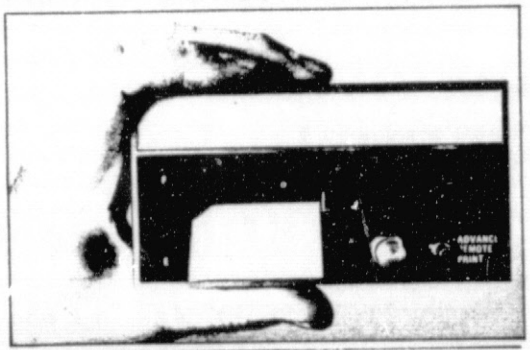
Standard 1-¾" wide thermographic papers are used in handy 150 foot rolls giving about 9,000 lines per roll with 5 lines per inch. The 7-segment digits are .155" high with left-of-digit decimal points selectable at each digit. Seven column printing formats include sign and six digits or 2-channel (ident) digits, sign and 4 data digits. Other 7 column decimal formats are also available.

The DPP-7 Digital Panel Printer extends back 6.2" from the front surface of the mounting panel (8.62" for the AC powered versions), including space allowance for the two 30-conductor PC board connectors or AC fuses.

Three universal AC line voltages (100, 115, and 230 VAC) will power the DPP-7 Printer as well as +5VDC at 20 watts average (8 Amps peak).

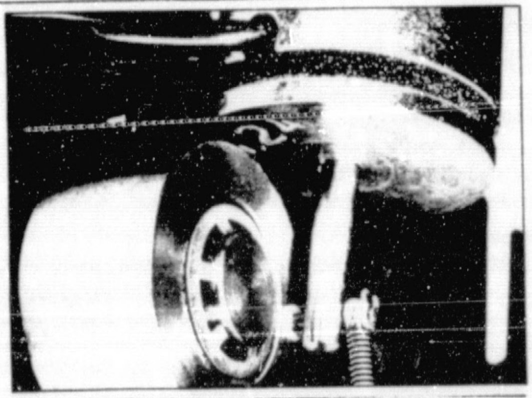
The DPP-7 is ruggedly built, using a simple, but sophisticated mechanical design which is optimized for heavy duty OEM applications. A proprietary printhead character coating allows the head to be conservatively rated at 3 million lines.

# HIGHLIGHTS



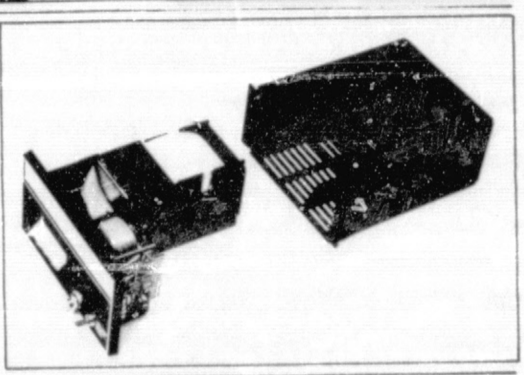

### 2.3 Lb. Panel-Mounting Featherweight

At 2.3 pounds (1,1Kg) the DPP-7 DC version is one of the lightest panel-mounted recording instruments available. It is directly compatible with the size, shape and interfacing of Digital Panel Meters.



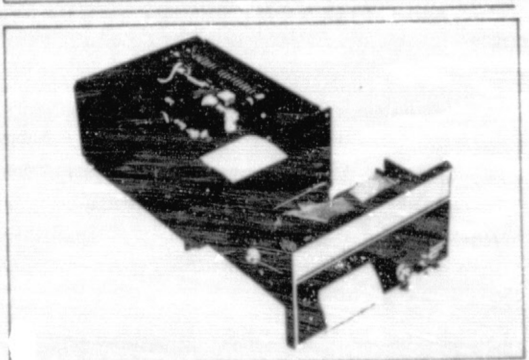
### OEM Reliable – only Two Moving Parts

Instead of the usual assembly of ratchets and gears, the DPP-7 Digital Panel Printer needs only two long-life moving parts – a linear solenoid and rotary clutch. Two 1/8" excursions of this solenoid connected to the one-direction rotary clutch cause one line advance. There are no banging hammers or twirling printwheels to fail and to cost extra in assembly. All electronics use low power Schottky TTL logic, assuring minimal heat rise and long, service-free life. Components have been generously derated and were selected particularly for their OEM reliability. A full one-year warranty provides further assurance of product excellence. An absolute minimum of maintenance is needed. Printhead cleaning required in other thermal printers can safely be ignored because of the wiping action of the paper.



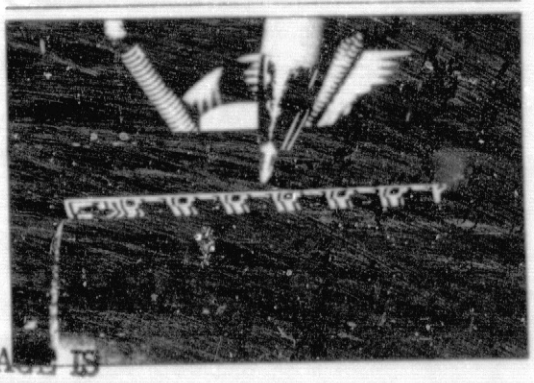
### Complete with Binary Coded Decimal Inputs

Datel's Miniature DPP-7 Printer is complete with BCD electronics. Many competitive printers don't include full parallel BCD or if they do, it is an expensive additional chasses with bulky cabling and unique power requirements. Datel's little DPP-7 printer is ready to use and all BCD I/O logic (with selectable positive or negative true TTL coding) is built in.



### +5VDC or AC Line Powered

Take your pick of power voltages. Use either +5 Volts DC or 100, 115, or 230 Volts AC, 47 to 440 Hz. The +5VDC printer offers the smallest package, only 6.2 inches (158 mm) deep and only 2.3 pounds (1,1Kg). The +5V version requires a regulated power supply capable of 8 Amps peak during print cycles while the AC version can accept a variety of universal worldwide power voltages and is slightly longer than the DC version.



### Thermal Printhead

Printing couldn't be simpler. Heat-sensitive thermographic paper is positioned under six decimal digits in 7-segment format. Each digit consists of conductive thickfilm resistor matrix segments deposited on a ceramic substrate. Segment-parallel, digit-serial power pulses are applied to each digit for 25 milliseconds. $I^2R$ heating then darkens the paper in contact with the heated segments, leaving crisp, black printed digits. A proprietary, thermally conductive surface on the thickfilm elements has high wear resistance allowing a conservative 3 million line printhead life. Characters are formed along the bottom edge of the printhead so they may be viewed immediately after printing.

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# SPECIFICATIONS (TYPICAL @ +25°C UNLESS NOTED)

## General

**Number of columns:** 7

7-column formats available:

a) Leading ± sign and 6 decimal digits
b) 2 leading ident or channel digits, ±sign and 4 data digits

**Decimal digit format:**
7-segment 0 to 9 digits .155" (4 mm) high with 10° slant and selectable left decimal point.

**Printing method:**
Thick film thermal print head, black characters on white paper (using 3M Type 161 paper)

**Printer paper:**
1.75" wide x 150 feet long, (44.5 mm x 45 m), 3M-type 161 thermal paper roll with the thermal surface facing away from the center of the roll.

**Paper advance:**
Via linear solenoid and one-direction rotary clutch.

## Performance

Max. printing rate: 3 lines per second
Print and paper advance cycle: 330 milliseconds
Line spacing: 0.2 inch (5 mm)
Line density: 5 lines per inch
Line capacity per paper roll: approx. 9,000 lines
Minimum print head life: 3 million lines
Average print pulse on-time: 25 mSec. (height varied by temperature feedback)

## Inputs

DTL/TTL compatible, selectable positive or negative true, level sensitive. TTLLS low power Schottky logic used on all inputs.

**Logic Levels:**

| | | |
|---|---|---|
| Positive true: | $+2.0V \leq$ "1" $\leq +5.0V$ | Note TTLLS logic levels |
| | $0V \leq$ "0" $\leq +0.5V$ | |
| Negative true | $0V \leq$ "1" $\leq +0.5V$ | |
| | $+2.0V \leq$ "0" $\leq +5.0V$ | |

Note: Pullup resistors to +5V may be optionally removed on all inputs and outputs.

**Data: (24 lines)**
Full parallel BCD (1-2-4-8), selectable positive or negative true, 1 TTLLS load plus 10 K ohm pullup to +5V. May be used with Form A (normally open) or Form B (normally closed) switch closure inputs. Level sensitive (rise-time non-critical).

**Change Data Polarity: (Pin C1-B11)**
Selects input polarity of data, decimal points and ± sign simultaneously.
LOW = positive true coding
HIGH = negative true coding
6 TTLLS loads, plus 1 K ohm pullup to +5V, level sensitive

**Print and Advance Command: (Pin C1-B14)**
Level sensitive for Form A or Form B contact closure, selectable positive or negative true.
1 TTLLS load plus 10K ohm pullup to +5V.

Pulse Width: 1 miscrosecond to 200 mSec (data must be valid 1 μsec. after leading edge and 500 nSec. before the print command).
Maximum print command rate: 3 per second.
Paper advance automatically occurs after digit printing. Holding print command TRUE longer than the busy output is true (200 to 330 mSec, typ) causes continuous 3 lines/sec. printing.

**Change Print Polarity: (Pin C1-B7)**
HIGH = negative true coding
LOW = positive true coding
1 TTLLS load, plus 10K ohm pullup to +5V, level sensitive.

**Leading Zero Suppress: (Pin C1-B4)** blanks all leading zero's to the left of decimal point except a zero just left of the decimal point
HIGH = Leading 0's blanked
LOW = full print (no suppression)
2 Low Power TTL loads, plus 10K ohm pullup to +5V, level sensitive.

**Minus Sign: (Pin C1-B1)**
Selectable positive or negative true using data level select input.
1 TTLLS load, plus 10K ohm pullup to +5V, level sensitive.

**Plus Sign: (Pin C1-A5)**
(Selectable positive or negative true using change data polarity input). (Minus sign must also be printed since it is used as the horizontal portion of the plus sign).
1 TTLLS load, plus 10K ohm pullup to +5V, level sensitive.
Note: Printing "plus" sign only results in vertical portion of plus sign. See above. Usable as 100% overrange digit.

**Blanked Character:**
Created by loading 1-1-1-1 in a given column. Can be hard-wired.

**Decimal Points: (6 lines)**
1 TTLLS load, plus 10K ohm pullup to +5V, level sensitive.
(Selectable positive or negative true using change data polarity inputs).

**No-Print Paper Advance: (Pin C1-A3)**
Ground this line 70±5 mSec to advance one line. Hold to ground for continuous advance at 6.7 lines per second.
1 TTLLS load plus 10K ohm pullup to +5V.

**No Print Paper Advance:**
May also be created by loading the illegal BCD character 1-1-1-1 in all decimal locations, and disabling all decimal points and ± signs, then initiating a print/advance command.

**Test: (Pin C2-B6)**
LOW = ± .8 .8 .8 .8 .8 .8 printout when print/advance command is given.
1 TTLLS load, plus 10K ohm pullup to +5V, level sensitive.

**Change Busy Polarity: (Pin C1-A2)**
HIGH = positive true busy out
LOW = negative true busy out
1 TTLLS load, plus 10K ohm pullup to +5V, level sensitive.

GROUND C1-B11 AND C1-B7 FOR POSITIVE TRUE INPUTS. DON'T FLOAT

# SPECIFICATIONS

## Outputs

**DTL/TTL compatible**

Positive true: 0V ≤ "0" ≤ +0.4V
+2.4V ≤ "1" ≤ +5.0V

Negative true: +2.4V ≤ "0" ≤ +5.0V
0V ≤ "1" ≤ +0.4V

**Busy: (Pin C2-B12)** (Open collector TTL 7438 with 1K ohm pullup to +5V)

Remains TRUE during print and advance cycle (approximately 200 to 330 milliseconds). Data inputs may be changed 500 nSec. after transition to TRUE. Next print command can be enabled when busy goes FALSE. Selectable positive or negative true. 10 TTL loads.

**Out of Paper: (Pin C2-B4) see dwg. pg. 10**

Switch opening via mechanical pawl when approx. 6' (2m) of paper are left on roll. Paper roll visually indicates "low paper" within 10 to 15 feet (3 to 4.5m) of end of roll using red stripe on roll. Switch is in series with PC board contacts which disconnect if printer mechanism is not completely seated in case. Open switch contacts or print mechanism removed will disable both local and remote print command. Pin C2-B4 has an internal 1K ohm pullup to +5V normally grounded by switch before paper is low.

## Front Panel

**LED red power-on lamp**

**Paper Quantity Indicator:**

Mechanical pointer which rides on paper roll, indicating relative amount of paper left.

**Paper Roll Replacement:**

By sliding out front panel printer assembly. PC board interlock automatically disconnects all power to printer assembly and power supply with electronics remain with housing case. Removal by a single Dzus-type front panel thumbscrew.

**Print/Remote/Advance**

Front panel 3 position toggle switch, stable in center position (REMOTE), must be held in top (ADVANCE) or bottom (PRINT) positions.

ADVANCE:

When switch is held up, the printer continuously advances paper without printing at a 6.7 line per second rate. Paper may be manually advanced simply by pulling paper out of front opening at any time.

REMOTE:

Center position enables all external inputs.

PRINT:

When switch is pushed down, printer prints one line and stops. After print and advance, external input is accepted even if the switch is held down.

## Temperature Ranges

**Operating:** 0 to +40°C (to +50°C at derated speed)
**Storage:** -25°C to +85°C (Paper darkens above +60°C)
Active printhead temperature sensor is employed to maintain proper print head temperature at all ambient temperatures and during warmup.

## Power Supply

**+5 Volt Version:**

4 Amps average current (20 watts dissipation) at 3 lines/sec. max. printing rate. (10 Watts, typ in standby)

Segment-parallel, character-serial printing requires +5V @ 8 Amps peak, duty cycle is 10 to 90% during print and advance period.*

Separate PC board connection available to supply "clean" (±2% @ .3 Amp) 5 volts to logic section. Logic spikes must be held to 50mV max. pk-pk.

Unregulated +5V (±10%) connected through 1/4" spade terminal connector, 16 gauge wire or larger not to exceed ten feet (3 meters).

**Fuse:**

7 Amp SLO-BLO, 1/4" x 1-1/4"

*8 Amp current pulses on and off during print and advance cycle from 10 to 90% duty cycle (depends on character printed, leading zeros, etc.). 8 Amp, 5 to 20 msec. pulses occur several times per second in standby.

Power consumption varies with print rate, leading zeroes, digits printed, signs and decimal points.

## Power Supply

**AC Version:**

105-125 VAC, 57-63 Hz @ 40 watts max (10 watts, typ standby)

**Optional:**

205-240 VAC, 47-63 Hz @ 40 watts max (10 watts, typ standby)

**Optional:**

90-110 VAC, 47-63 Hz @ 40 watts max (10 watts, typ standby)

**AC Fuse:** 1/4" x 1-1/4" Buss MDL or equivalent 1/2 A, SLO-BLO, 115VAC, 1/4A, SLO-BLO, 230 VAC.

Note: Case is isolated from 5V ground and AC line. A separate spade terminal is included to ground case.
+5V, 200mA max. logic power out available with AC version.

## Connectors

**Data and Controls:** (and optional logic +5V)

(2)30-conductor (15 per side).
Double-sided PC board connectors.
0.1" centers, Viking #3VH15/1JN-5 or equivalent ($3.95 each, 2 included with printer).

**+5V Power**

(2) 1/4" spade terminal connectors, included.

**AC Power**

(1)Double 1/4" spade terminal connector. Mates to a 9115 AC line cord (included).

## Weight (with housing and full paper roll)

| | | |
|---|---|---|
| 5 Volt Version: | 2.3 lbs. | (1,1Kg) |
| AC Version: | 4.2 lbs. | (1,9Kg) |

## Dimensions (Uses #4 hardware)

Front panel mounting cutout:
4.50" WIDE x 2.72" HIGH (115 mm x 69 mm)

Front panel Bezel dimensions:
5.25" WIDE x 2.82" HIGH (134 mm x 72 mm)

Depth behind front surface of mounting panel including clearance for rear PC connectors and fuses:

5V Version: 6.2" (158 mm)
AC Version: 8.7" (221 mm)

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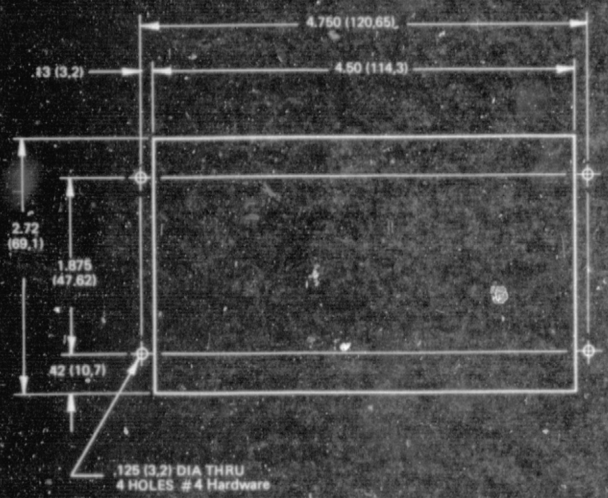
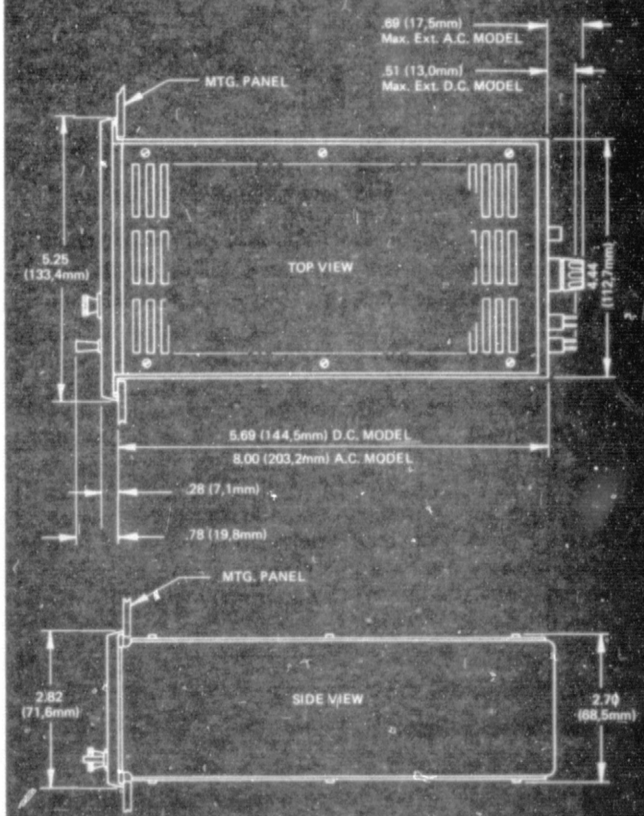
# MECHANICAL DIMENSIONS

## PANEL CUT-OUT
## INCHES (MILLIMETERS)

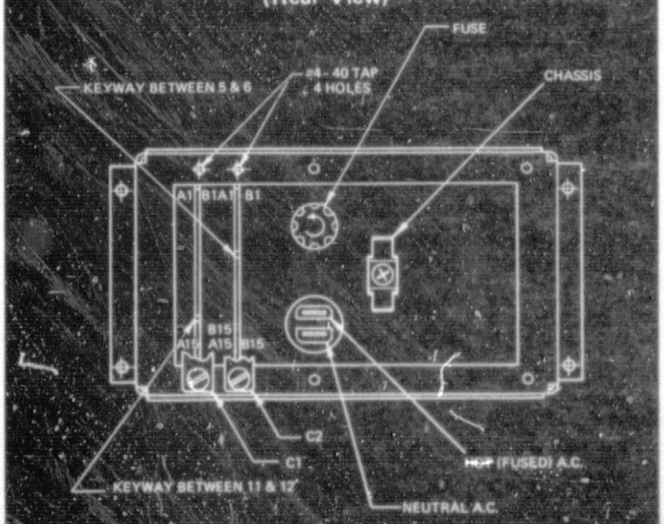



NOTE:
1. DIMENSIONS IN INCHES (mm)
TOLERANCE: .XX ±.01 (0,25)
.XXX ±.005 (0,10)

## OUTLINE DIMENSIONS A.C. & D.C. MODELS
## INCHES (MILLIMETERS)

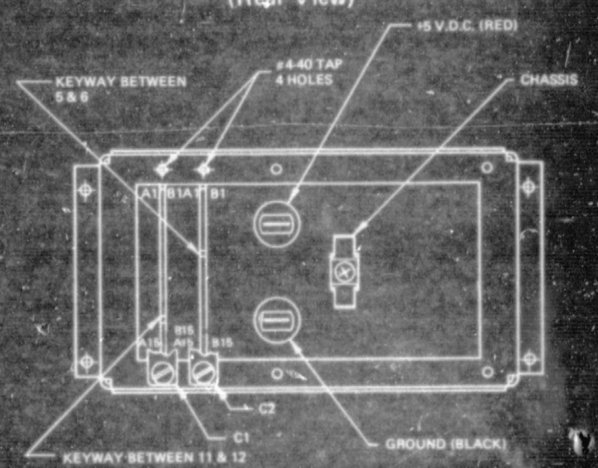



## A.C. MODEL POWER AND LOGIC CONNECTIONS
## (Rear View)




NOTE:
1. POWER INPUT & CHASSIS CONNECTIONS ARE 1/4" (6.35mm) MALE SPADE TERMINALS.
2. C1 & C2 ARE VIKING #3VH15/1JN5 OR EQUIVALENT (INCLUDED WITH PRINTER).

## D.C. MODEL POWER AND LOGIC CONNECTIONS
## (Rear View)




NOTES:
1) PRINT POWER INPUT & CHASSIS CONNECTIONS ARE 1/4" (6.35mm) MALE SPADE TERMINALS.
2) RECOMMENDED WIRE SIZE IS #16 AWG. OR HEAVIER 10ft. (3m) OR LESS.
3) FOR CURRENT CHARACTERISTICS, SEE TIMING DIAGRAM.
4) THE FUSE FOR THE 5 V.D.C. LINE IS LOCATED ON THE INSIDE OF THE UNIT. SEE PAGE 10 FOR REPLACEMENT.
5) COMBINED LINE DROP REGULATION 5V ± 10%
6) LOGIC POWER 5V ±2% AT .3 AMPS IS TO BE BROUGHT IN SEPARATELY THROUGH C1 AND/OR C2.
7) C1 & C2 ARE VIKING #3VH15/1JN5 OR EQUIVALENT (INCLUDED WITH PRINTER).

# INPUT/OUTPUT CONNECTIONS

**DDP-7 PRINTER PINOUT**

Refer to the drawings on the bottom of page 6.

**Connecter Pinouts Are Shown As Viewed From Rear Of Printer**

| | Connector C1 A | Connector C1 B | | Connector C2 A | Connector C2 B | |
|---|---|---|---|---|---|---|
| 1. | Dec Pt .0000 | Sign "—" | 1. | BCD 8,000 | BCD 800,000 | 1. |
| 2. | Chg. Busy Polarity | Dec Pt .00000 | 2. | | BCD 80,000 | 2. |
| 3. | No Print Advance | Dec Pt .000000 | 3. | | | 3. |
| 4. | Logic & Pwr. Gnd. | Leading Zero Suppress | 4. | | End of Paper | 4. |
| 5. | Sign "I" | | 5. | | Logic & Pwr. Gnd. | 5. |
| 6. | Dec Pt .0 | Dec Pt .000 | 6. | | Enable Print Test | 6. |
| 7. | Dec Pt .00 | Chg. Print Polarity | 7. | | BCD 800 | 7. |
| 8. | BCD 400,000 | BCD 80 | 8. | BCD 200,000 | BCD 20,000 | 8. |
| 9. | BCD 20 | BCD 8 | 9. | | | 9. |
| 10. | BCD 2 | BCD 40,000 | 10. | | BCD 2,000 | 10. |
| 11. | BCD 100,000 | Chg. Data Polarity | 11. | | BCD 200 | 11. |
| 12. | BCD 10,000 | | 12. | | Busy | 12. |
| 13. | BCD 40 | +5V Logic Power | 13. | BCD 1,000 | +5V Logic Power | 13. |
| 14. | BCD 400 | Print Command | 14. | | BCD 10 | 14. |
| 15. | BCD 4,000 | BCD 4 | 15. | BCD 100 | BCD 1 | 15. |

NOTES

1. +5V contacts (C1-B13 & C2-B13) are internally connected
2. Ground contacts (C1-A4 & C2-B5) are internally connected
3. On DC Models, +5V Contacts (C1-B13 & C2-B13) are used for logic power input (5V ±2% @ .3A, logic spikes less than 50mV, pk-pk). These +5V logic power contacts may be connected to the high current +5V spade terminal if external regulation will hold +5 ± .25VDC at the printer while printing. (Current 8 Amps max)
4. On AC Models, +5V contacts (C1-B13 & C2-B13) will provide +5V power out at 200mA max.

**GROUND C1-B11 AND C1-B7 FOR POSITIVE TRUE INPUTS. DON'T FLOAT.**

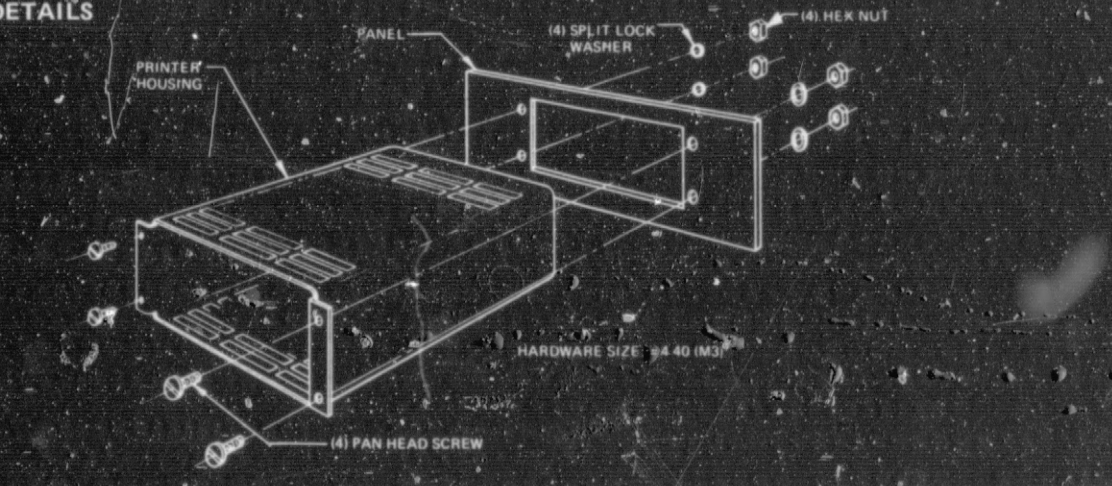
**BCD INPUTS** Binary Coded Decimal inputs are shown cross-referenced to their corresponding connectors and pins.

For other print formats (see ordering guide, pg. 12) blanked columns will appear between digits shown.

| CONNECTOR | 100,000's DIGIT 6 | | | | 10,000's DIGIT 5 | | | | 1,000's DIGIT 4 | | | | 100's DIGIT 3 | | | | 10's DIGIT 2 | | | | 1's DIGIT 1 | | | | CONNECTOR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8 | 4 | 2 | 1 | 8 | 4 | 2 | 1 | 8 | 4 | 2 | 1 | 8 | 4 | 2 | 1 | 8 | 4 | 2 | 1 | 8 | 4 | 2 | 1 | |
| C1 | | A 8 | | A 11 | | B 10 | | A 12 | | A 15 | | | | A 14 | | | B 8 | A 13 | A 9 | | B 9 | B 15 | A 10 | | C1 |
| C2 | B 1 | | A 8 | | B 2 | | B 8 | | A 1 | | B 10 | A 13 | B 7 | | B 11 | A 15 | | | | B 14 | | | | B 15 | C2 |

± sign located here on type 2 print format

## MOUNTING DETAILS



# PAPER LOADING

### HOW TO LOAD PAPER

1. Shut off all power to the printer if the printer uses a separate power switch.

2. Slide out the printer mechanism by first loosening the front panel thumbscrew counterclockwise until it stops. Pull the thumbscrew firmly straight out and the front panel/printer assembly will slide out all the way. Some force may be needed to release the internal PC connection.

3. Raise the paper loading door by pulling forward until it stops. This automatically lifts the thermal printhead from the paper drive roller (see photo). Remove any paper from a previous roll.

4. Pull the remaining paper backward out from under the printhead. Grasp both ends of the paper roll axle with fingertips and pull straight up out of the printer assembly. The axle will slide past the circular axle retaining spring as shown in the photo.

**Inserting new roll**

5. Slide the paper roll axle out of the used paper roll and reinsert the axle in a new roll. Do not discard axle!!! The paper roll is Datel part number 9101 supplied only in boxes of ten rolls. Order box number 9114 ($19.95). Spare axles are Datel part number 9062, $5 each.

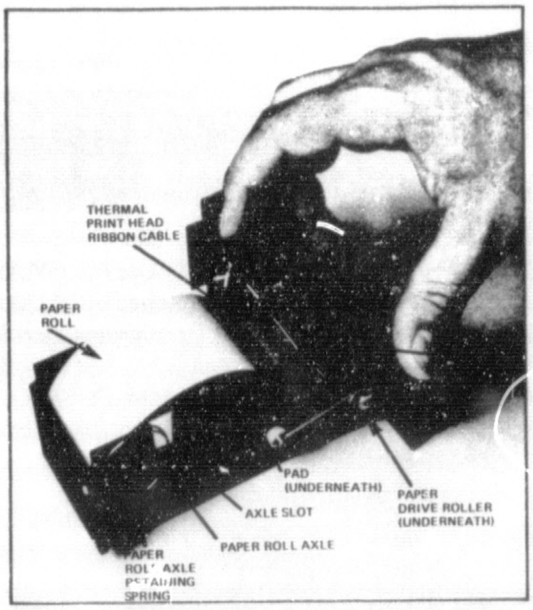
6. Slide the new roll and the axle past the retaining spring and insert the paper over the pad and under the printhead ribbon cable (see photo) until paper appears at front panel slot. Be sure the paper is threaded from the rear and passes over the roll. Paper should be cut straight across for easy insertion. Only the outside paper surface is treated for printing.

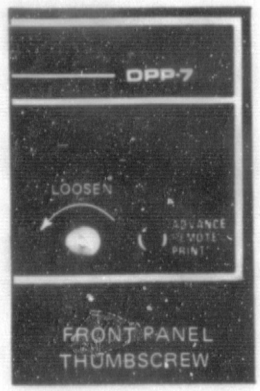
7. Pull paper through front panel slot, close the paper loading door and slide the printer mechanism back into the housing. Press the front panel printer assembly firmly into the housing as far as it will go. This will seat the internal PC board connection.

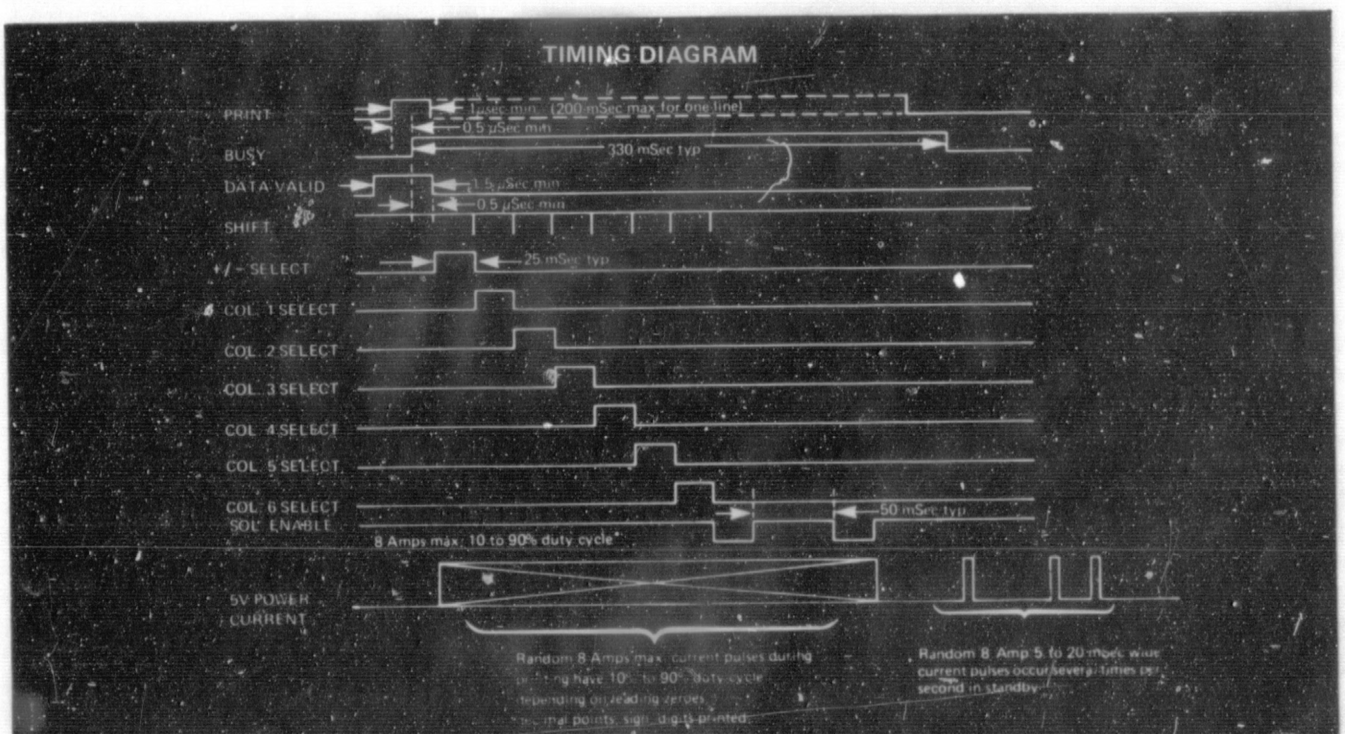
8. Rotate the thumbscrew clockwise until it stops and turn on power. Paper may be manually advanced simply by pulling out of the front slot.

**Reloading summary:**

1. Loosen thumbscrew, pull out mechanism.
2. Lift paper loading door.
3. Lift out used roll and reinsert axle in new roll.
4. Press new roll and axle into axle slot past circular spring.
5. Thread paper over top of roll and under printhead out through front panel slot. Close door.
6. Push mechanism back into housing and retighten thumbscrew.



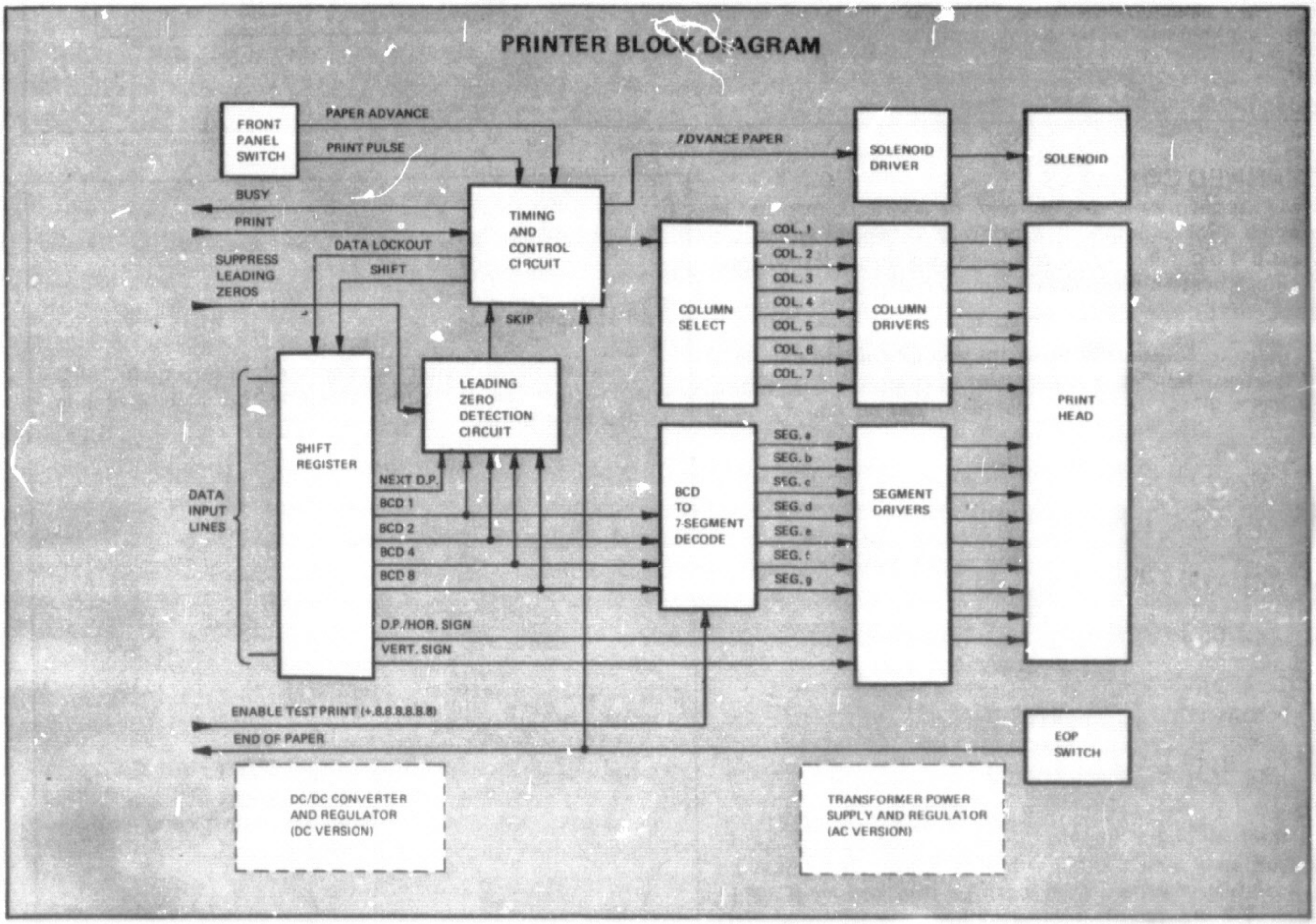
# APPLICATIONS

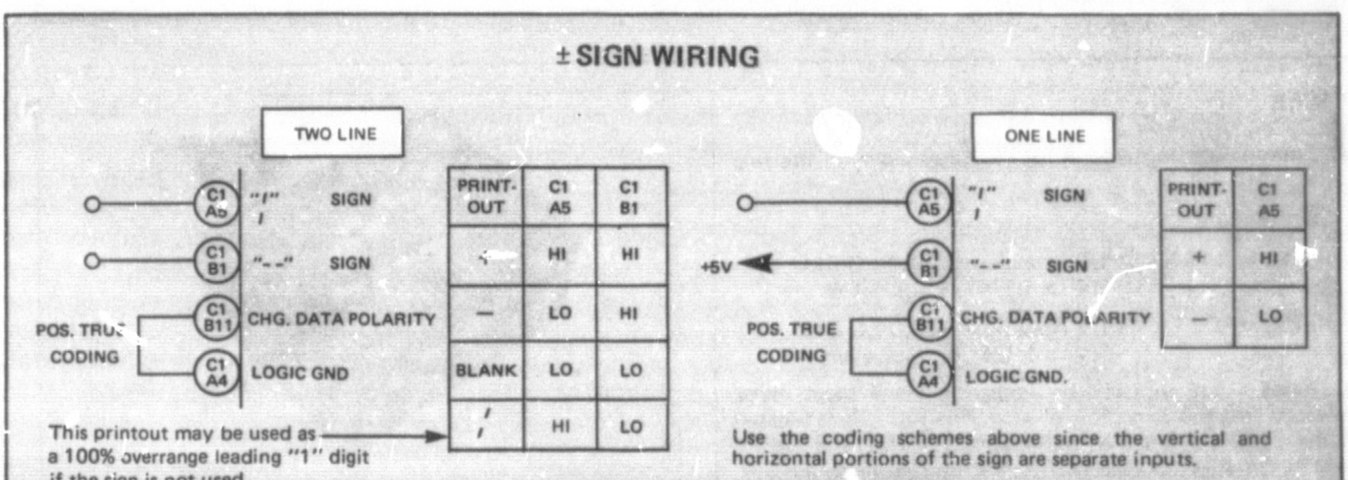
An ideal use for the DPP-7 is to record analog values from a BCD output A/D converter or Digital Panel Meter. A simple external clock circuit or an A/D converter with an adjustable conversion rate can be used to form a printing data logger. With the addition of Datel's digital time-of-day clock and data acquisition module, a complete multi-channel logging system can be made. See page 11.

Most scientific and analytical instruments with digital interfacing capability will have full parallel BCD outputs which can be directly connected to the DPP-7.

Use the DPP-7 with Datel's autoranging DM-2000AR Digital Panel Meter to create an analog sampling system with 3-½ digit resolution over 3 decades from 200mV to 20V full scale. See page 11.

Using the DPP-7 printer with a DPM will allow faster sampling than taking readings by hand or by visual sampling of the DPM readout. Longer-term variations and drifts are more easily viewed when the printer and DPM work hand-in-hand.




| PRINT-OUT | C1 A5 | C1 B1 |
|---|---|---|
| + | HI | HI |
| − | LO | HI |
| BLANK | LO | LO |
| / / | HI | LO |

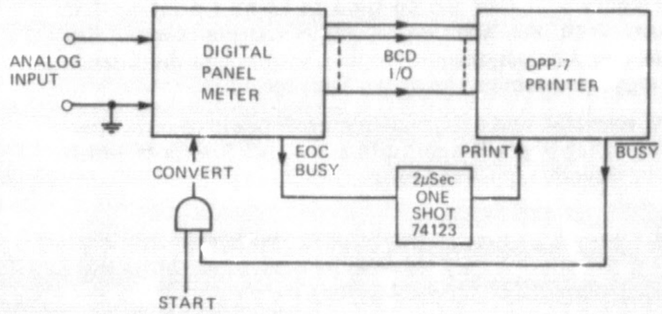
| PRINT-OUT | C1 A5 |
|---|---|
| + | HI |
| − | LO |

## APPLICATIONS

### BCD Source to Printer Block Diagram

When used with a Digital Panel Meter or A/D converter with BCD output, the interconnections with the Printer are made as shown here. The converter or DPM's output connects to the printer input. The EOC (Busy) output generates a print pulse using a monostable and a system gate inhibits further conversions until the print and advance are completed.

A basic interface of this type is detailed in the circuit on page 11. More logic may be required if any coding is inverted although this may be accomodated by the selectable coding feature of the DPP-7. Some types of conversion systems might require time-synchronous levels and would need more circuitry than shown here. Important circuit details have been omitted for clarity.

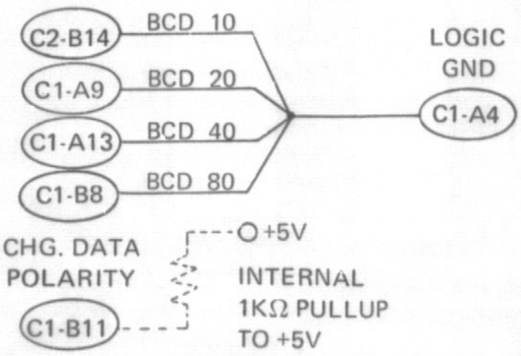



### BLANKED COLUMNS

Many applications require one or more columns to be blanked. For example, if a printout is needed which displays a 4-digit data value with sign and then a 0 to 9 channel identification digit, the printout would be:

±9999 9

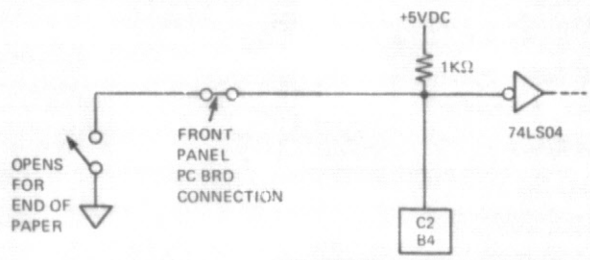
In order to continually blank the second column, the illegal BCD digit 1-1-1-1 is hard-wired as follows. The typical example shown here assumes negative true coding:




The data is negative true because pin C1-B11 is floated and the internal pullup resistor to +5V automatically causes negative true data coding. Other columns can be blanked in a similar manner. With positive true coding (C1-B11 and C1-B7 grounded), internal pullup resistors on all BCD data inputs will automatically blank all unused columns.

### End of Paper Switch

The end of paper switch is connected in series with a PC board connector as shown. Opening the switch inhibits further print pulses.




END OF PAPER OUTPUT (PIN C2 - B4)

### FUSES

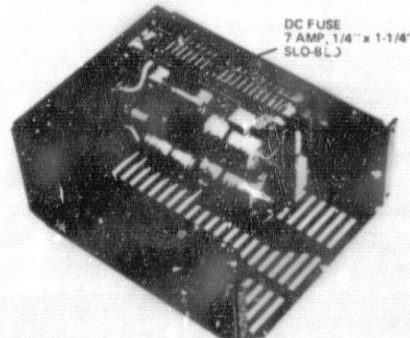
**AC Fuses** – are replaced using the fuseholder on the rear panel.

The fuses are:

100 or 115 VAC: 1/2 Amp Buss MDL SLO-BLO 1/4" x 1-1/4" or equivalent

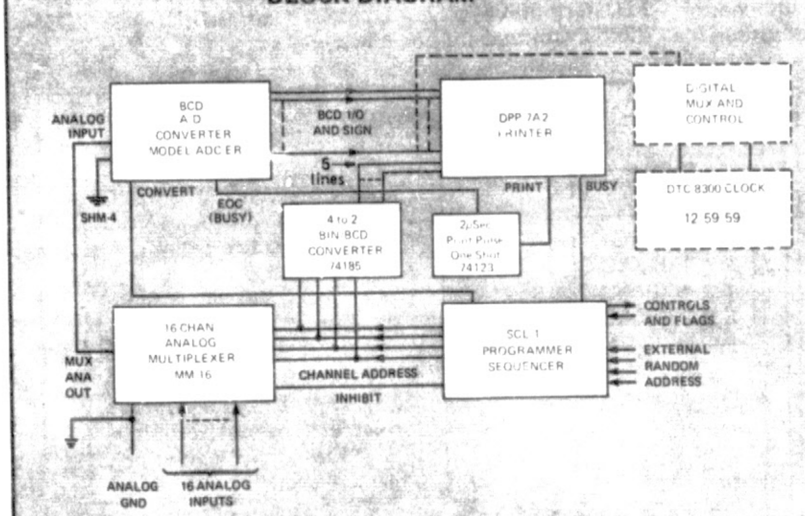
230 VAC: 1/4 Amp Buss MDL SLO-BLO 1/4" x 1-1/4" or equivalent

**DC Fuses** – are replaced by removing the 4 sheet metal screws and the top cover (see photo). The fuse clip is located on the top inside edge of the inner PC card. Use a 1/4" x 1-1/4" Littlefuse 3AG SLO-BLO 7 Amp fuse or equivalent.



# APPLICATIONS

TYPICAL 16-CHANNEL PRINTING DATA LOGGER
BLOCK DIAGRAM




The DPP-7 Printer can be combined with other Datel off-the-shelf modules to create a complete multichannel printing data logger as suggested here. Circuit details such as power, trim, hard-wired inputs, bypassing and full system logic have been omitted for clarity.

With the addition of Datel's Model DTC-8300 Digital Clock, a simple 2 channel digital multiplexer and control for the Printer input, the printout will also record the time of day at selected intervals. Contact Datel for applications assistance.

TYPICAL PRINTOUT:

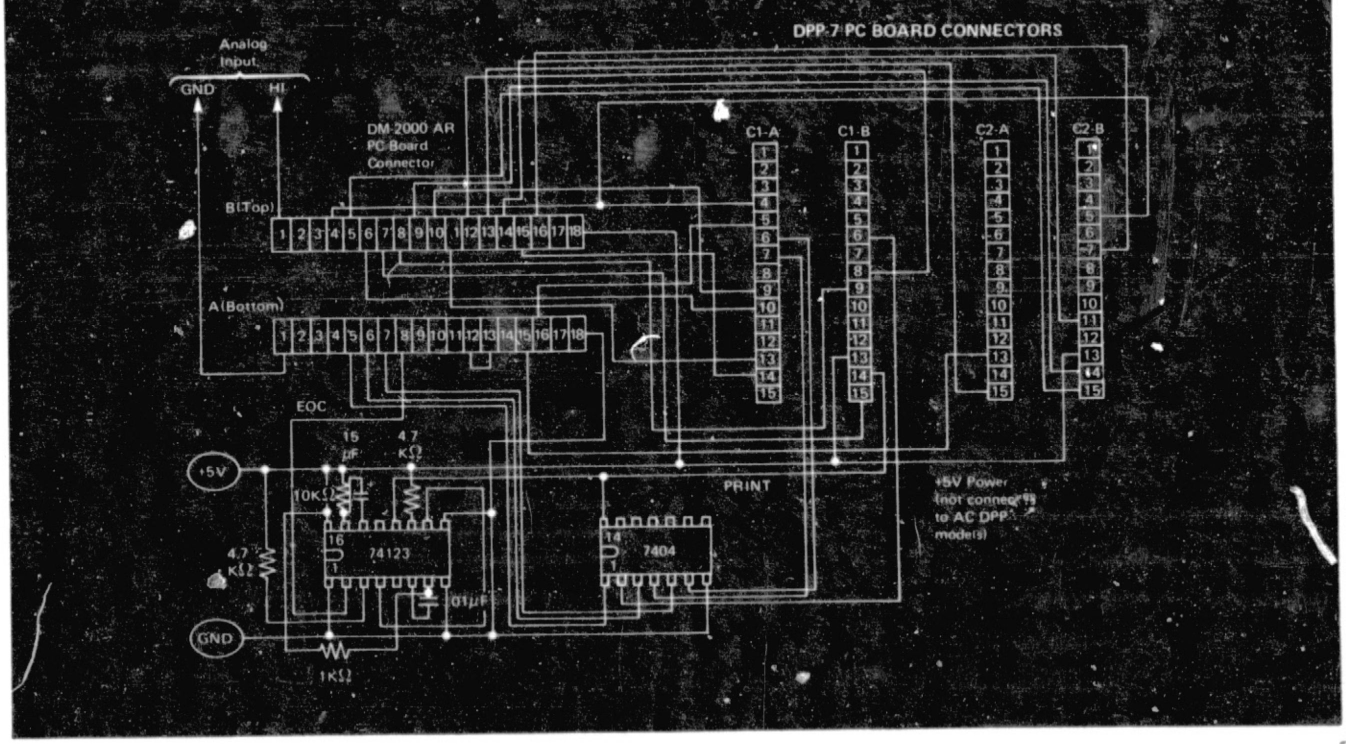
| CHANNEL | VALUE | |
|---|---|---|
| 07 | + 08.95 | DATA |
| 08 | - 12.36 | |
| 09 | - 04.47 | |
| 10 | + 10.12 | |
| " | " | |
| " | " | |
| " | " | |
| 16 | - 19.03 | |
| 12 | 59.59 | TIME |
| Hours | Min/Sec | |

APPLICATION EXAMPLE:

DIGITAL PANEL METER TO PRINTER INTERFACE

The typical interface circuit shown will connect a DPP-7 Printer and a Datel DM-2000AR Autoranging Digital Panel Meter. The DPM will shift decimal points over three full scale ranges (± .1999V, ± 1.999V, and ± 19.99V) and the DPP-7 Printer will automatically print out data with the sign and correctly positioned decimal points. The DM-2000AR Digital Panel Meter is internally set to make two samples per second of analog input voltages. The leading edge of the EOC (Busy) line from the DPM is used to trigger one of the monostables in the 74123 integrated circuit. Thirty-three milliseconds later, the EOC line is low and valid BCD data is available from the DPM. The first 50mS monostable times out and triggers the second monostable in the 74123. This second monostable produces a 2 microsecond print pulse. The next start pulse from the DPM's internal start clock commands another sampling interval and a printout 50 milliseconds after sampling. The entire operation is controlled by the DPM start clock at about 2 samples and printouts per second. This clock can be slowed down or controlled externally (see DM-2000AR data sheet).

DIGITAL PANEL METER INTERFACE



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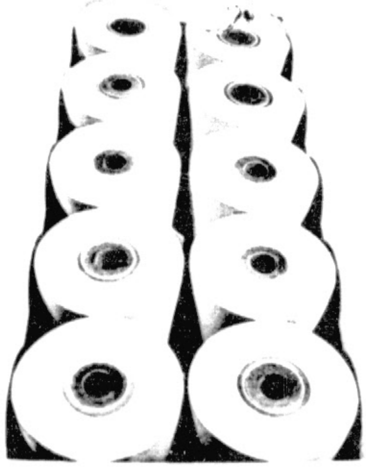
# ORDERING GUIDE & PRINT FORMATS

Datel's products are available both direct and through GSA. If you are connected with a military or federal agency or receive federal funds, you may be entitled to purchase Datel's Digital Panel Printers and other products through the General Services Administration to expedite requisitioning and order processing. Datel's printer is covered under FSC Group 66-17, Part II, GSA Contract No. GS-OOS-27959. Contact Datel for assistance.



Model 9114, Box of 10 paper rolls

### MODEL NUMBER

DPP-7 _ _

| Power |
|---|
| D = +5VDC |
| A = 115VAC |
| J = 100VAC |
| E = 230VAC |

| Print Format |
|---|
| 1 = ±.9.9.9.9.9.9 |
| 2 = .9.9±.9.9.9.9 |
| 3 = .9 .9.9.9.9.9 |
| 4 = .9.9.9 .9.9.9 |
| 5 = .9.9.9.9 .9.9 |
| 6 = .9.9.9.9.9 .9 |
| (Note: .9.9 .9.9.9.9 printout format can be derived from type 2 format by hard-wiring a blanked sign) |

| Prices (1-9) (includes 2 connectors, a roll of paper, and a 9115 line cord if an AC version). | | |
|---|---|---|
| | DPP-7 | $475.00 |
| | Model 9114, Box of 10 paper rolls, 150 ft. per roll | $ 19.95 |

## SALES OFFICES AND TELEPHONE NUMBERS *(For Applications Assistance Call Datel's Direct Offices)*

**NORTH AMERICA - Direct Offices**

| | | |
|---|---|---|
| Datel Systems (Home Office) | Canton, Mass. | 617-828-8000 |
| Datel Systems | Santa Ana, Calif. | 714-835-2751 |
| Datel Systems | Santa Ana, Calif. (LA Exchange) | 213-933-7256 |
| Datel Systems | Sunnyvale, Calif. | 408-733-2424 |

**INTERNATIONAL - Direct Subsidiaries**

| | | |
|---|---|---|
| Datel Systems GmbH | Muenchen, W. Germany | 089/78 40 45 |
| Datel Systems SARL | Paris, France | 603-06-74 |
| Datel KK | Tokyo, Japan | 499-0631 |
| Datel (U.K) Ltd. | Basingstoke U.K. | (0256) 66721 |

**AUTHORIZED SALES REPRESENTATIVES (N.A.)**

| | |
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| Huntsville, Alabama | 205-837-1601 |
| Phoenix, Arizona | 602-996-6130 |
| Westminster, Colorado | 303-427-5299 |
| Lighthouse Pt., Florida | 305-943-3076 |
| Longwood, Florida | 305-422-3686 |
| St. Petersburg, Florida | 813-441-1301 |
| Honolulu, Hawaii | 808-946-1533 |
| Chicago, Illinois | 312-585-5485 |
| Indianapolis, Indiana | 317-293-0696 |
| Olathe, Kansas | 913-782-1177 |
| Troy, Michigan | 313-524-2920 |
| Minneapolis, Minnesota | 612-544-9393 |
| Hazelwood, Missouri | 314-731-5200 |
| Raleigh, North Carolina | 919-834-3961 |
| Fort Lee, New Jersey | 201-224-6911 |
| Albuquerque, New Mexico | 505-345-2481 |
| Liverpool, New York | 315-622-2350 |
| Cleveland, Ohio | 216-486-0782 |
| Dayton, Ohio | 513-294-2838 |
| King-of-Prussia, Pennsylvania | 215-265-5211 |
| Pittsburgh, Pennsylvania | 412-243-1111 |
| Dallas, Texas | 214-238-7157 |
| Houston, Texas | 713-783-290[illegible] |
| Arlington, Virginia | 703-522-[illegible]666 |
| Seattle, Washington | 206-938-4166 |
| Milwaukee, Wisconsin | 414-464-5555 |
| Montreal, Canada | 514-389-8051 |
| Ottawa, Ontario Canada | 613-237-6150 |
| Rexdale, Ontario Canada | 416-678-0401 |

**AUTHORIZED SALES REPRESENTATIVES (Foreign)**

| | |
|---|---|
| Digital Electronics (Mktg.) Pty., Ltd. Sydney, Australia | 43 6668 |
| Bacher Elektronische Gerate Ges. MBH Vienna, Austria | 83 63 96 0 |
| Sotronic S.A., Brussels, Belgium | 734-58-68, 734-63-96 |
| A/S Danbridge Copenhagen, Denmark | (01-27) Asta 1575<br>(01-77) Sundby 4106 |
| Havulinna Oy, Helsinki, Finland | (90) 661451 |
| MTI Engineering [illegible] Tel Aviv, Israel | 244090, 236334 |
| 3G-Electronics s.r.l, Milano, Italy | 544291, 543096 |
| Techmation, Amsterdam, The Netherlands | 020-456955 |
| David J. Reid Ltd. Auckland 1, N.Z. | 492-189 |
| Morgenstierne & Co. A/S Oslo 5 Norway | 37 29 40 |
| Peter Jones Elec. Equip. (Pty.) Ltd. Johannesburg, S. Africa | 22-3658 |
| Aupoca Electronica y Sistemes Madrid 16, Spain | 457-53-12 |
| AB Nordqvist & Berg Stockholm, Sweden | 08-69-04-001 |
| Intertest AG, Bern, Switzerland | 031/2[illegible]481 |

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